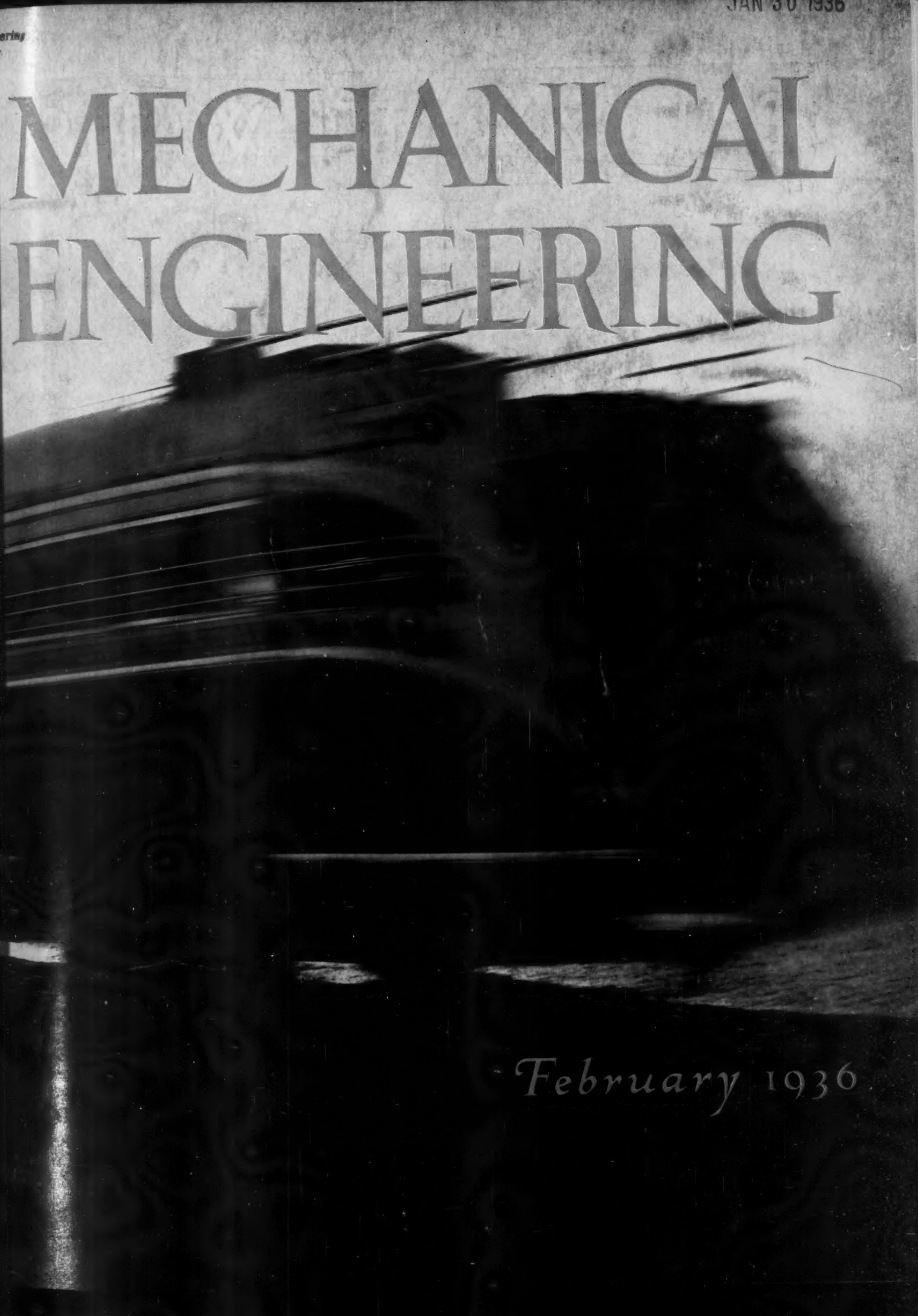
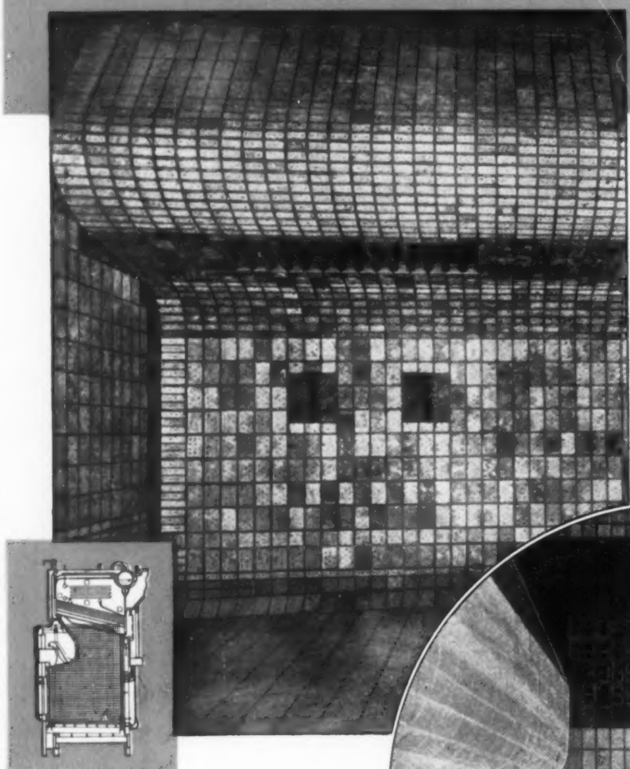
MECHANICAL ENGINEERING

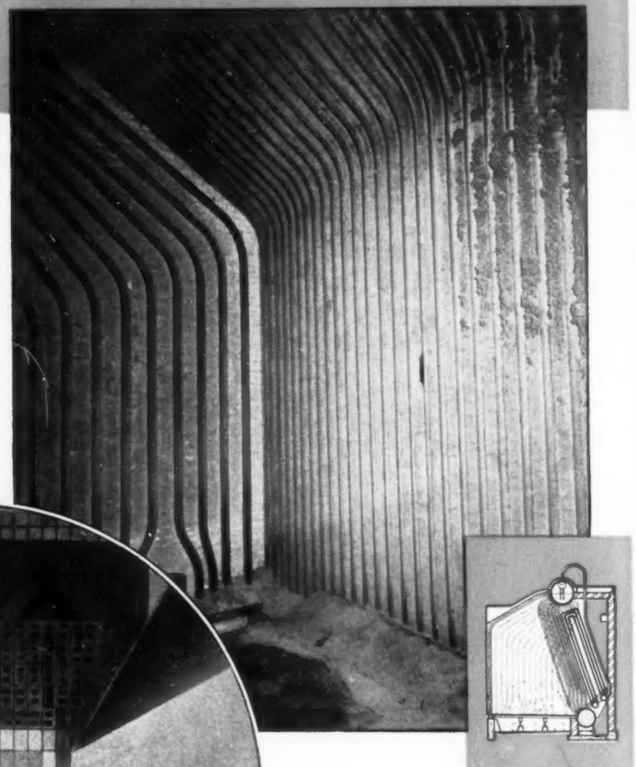


February 1936

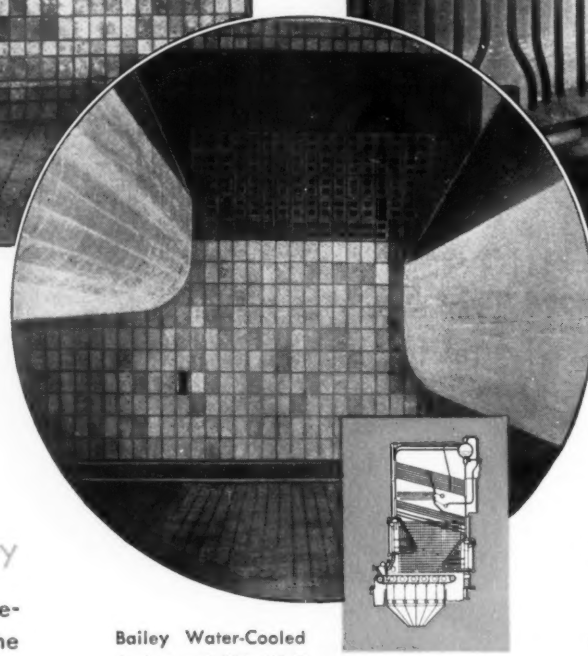
BAILEY WATER WALLS



Interior of Bailey Water-Cooled Slag-Tap Furnace showing block-covered side-wall and floor and multiple-inter-tube pulverized-coal burners located in the arch.



Bailey Water-Cooled Furnace Construction of the Integral-Furnace Boiler showing bare-tube rear wall, stud-tube side wall, and block-covered water-cooled floor.



Bailey Water-Cooled Arches and Side Wall of a chain-grate stoker-fired furnace under a B&W Boiler.

HIGH AVAILABILITY

Operating records show furnace-availability as high as that of the best boilers.

FOR BEST OVERALL PERFORMANCE

Coordination with other B&W Equipment makes possible a complete boiler unit capable of producing steam at lowest cost when all factors are considered.

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Used to advantage with any fuel or firing method, for small as well as large boilers, for partial or complete water-cooling.

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Wide variety of wall surfaces permit furnace temperature high enough to prevent excessive carbon loss at all ratings.

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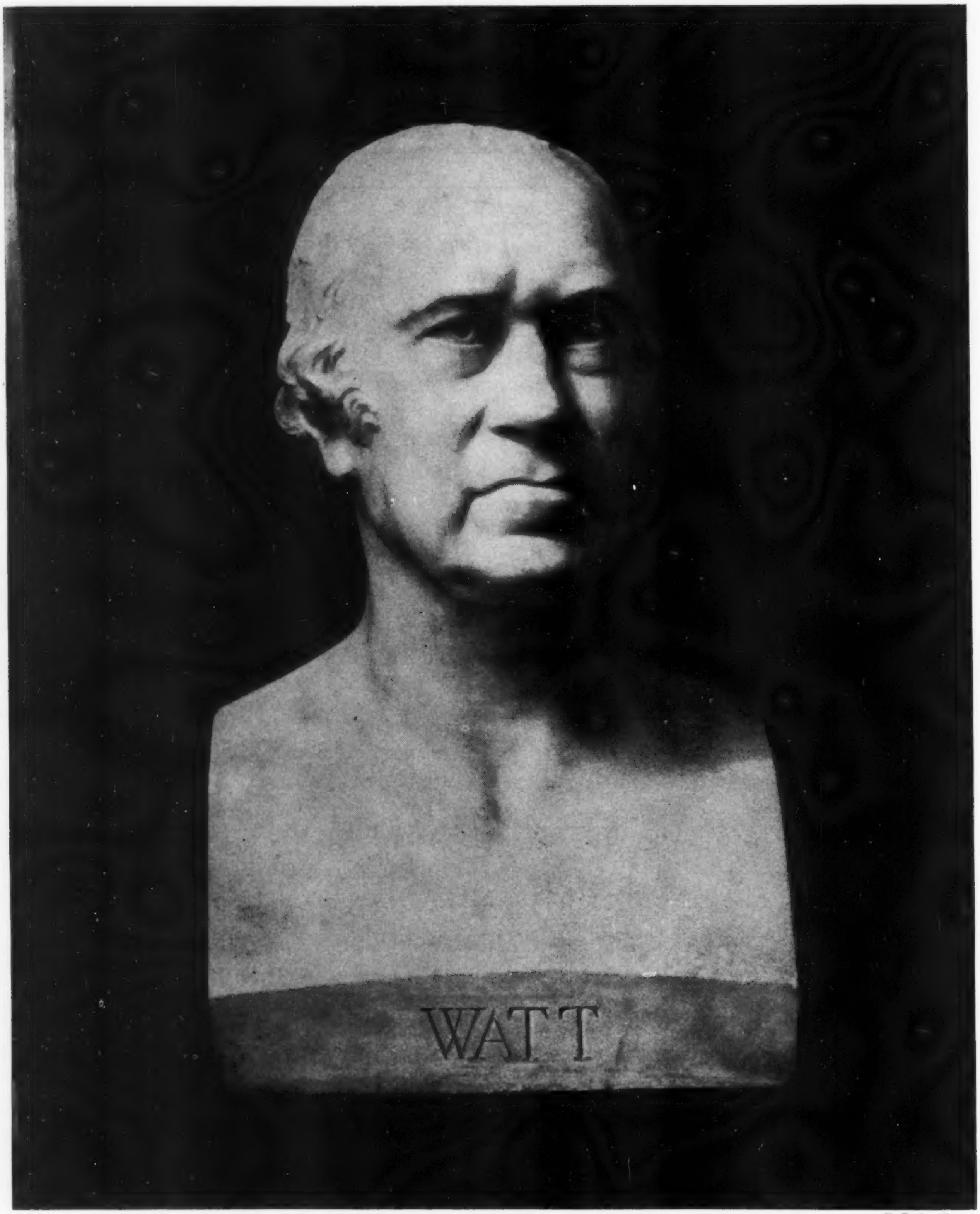


H. E. Angell

James Watt, 1736–1819

Photograph of Marble Bust Presented to the American Society of Mechanical Engineers by The American Society of Civil Engineers on the Occasion of the Watt Bicentenary

VOLUME 58
No. 2

MECHANICAL ENGINEERING

FEBRUARY
1936

GEORGE A. STETSON, *Editor*

A.E.C. Forges Ahead

ARISING to the challenge of an unprecedented national emergency which had grave effects upon engineers in particular, the American Engineering Council, whose annual meeting was held in Washington, January 9 to 11, demonstrated an effectiveness in dealing with public and professional affairs that elicits the warmest praise. An impartial observer of the record of the last few years of effort and accomplishment on the part of the Council will agree that it has justified the high hopes of its founders and proponents, silenced many of its critics, advanced the cause of unity in the engineering profession, made distinguished contributions to the intelligent administration of government agencies on a nonpartisan basis, assisted engineering groups and individuals, and enhanced the prestige of the profession, especially in official circles at Washington.

Backed by the loyal support of the many member organizations, the president, John F. Coleman, the staff, headed by Frederick M. Feiker and his assistant L. V. Reese, and the several important committees, in particular those groups under the Public Affairs Committee of which F. J. Chesterman acts as chairman, have succeeded splendidly in concrete accomplishments and in the contributions to sound and intelligent opinions and statements of policy on many matters affecting the public as well as engineering interest. To these individuals, and to all who worked with them, the thanks of the entire profession is due.

If intelligent and enlightened self-interest is an effective means of securing the public interest—and to this thesis we have continually adhered—the American Engineering Council has set an example which other organizations representing important minorities should follow. For it is unfortunately true that many such organizations think of themselves in terms which promote their own selfish interests at the expense of other groups or of the public welfare in general. Contrary to this attitude is that of the American Engineering Council which seeks, among other objectives, to render the best services it can in the public good by a critical, nonpartisan examination, frequently with the result of providing expert opinion on matters of public concern that aids in the proper planning or execution of important legislation; for as a class engineers are convinced that their own best interests are at one with the public's.

To this aspect of the work of the Council, its executive committee, its Committee on Public Affairs, and its member bodies have given an increasing measure of attention, as was attested in these pages some months ago, under the practical and enthusiastic leadership of Mr. Feiker. The impression made upon those who listened to the able reports read at Washington was so favorable that no dissenting voice was heard protesting at further and more extensive work along these lines. The reports themselves had the virtue of being informative and of dealing with principles and policies rather than details. The individual who belongs to one of the many member organizations that make up the Council has the satisfaction of knowing that the negligible amount of his personal monetary contribution to the work of the Council pays high dividends in social and professional values.

So effective is the Council's work, and so high its prestige, that contributions to its activities could easily be obtained were it to consent to further special and less public-spirited interests. But the Council wisely realizes that any such change in its policy would bring it and the engineering profession into discredit and frustrate its services to engineers and to the country. Only by following the course it has set for itself under such intelligent leadership as its eminent officers have given it can it retain the confidence of those in public and private life that look to it for advice and assistance. If every engineer will continue to back it up, the Council will continue to forge ahead in the service and to the honor of the profession.

A Timely and Significant Gift

THE bicentennial celebration of the birth of James Watt, recently held at Lehigh University and The Franklin Institute, makes unusually appropriate the generous gift of the American Society of Civil Engineers to The American Society of Mechanical Engineers of a marble portrait bust of that famous engineer, a photograph of which faces this page. This bust, constant reminder of one of the early masters of engineering, now becomes a cherished possession of the A.S.M.E.

In the terminology of his day Watt was a civil, as distinguished from military, engineer. But his work laid the foundation upon which mechanical engineering has since been based.

In this connection it is fitting to recall here that the Institution of Civil Engineers (Great Britain) was formed

one year before the death of Watt and incorporated years later in 1828. It is said that denial of membership in that society to the famous locomotive and railroad builder, George Stevenson, led to the formation in 1849 of the Institution of Mechanical Engineers, of which he was the first president. Thus a century ago was begun that decentralizing influence among practitioners in the engineering profession which extended to this country and resulted in the formation of our numerous societies devoting their energies to exclusive branches of engineering. Happily today that influence is abating, as incidents too numerous to mention amply testify; and in this country we find the major societies amicable neighbors under a single roof, jointly engaged in activities that tend to draw them more closely together. Of this significant spirit the gift of the American Society of Civil Engineers is but one of many happy reminders that distinctions based on fields of practice are disappearing in the realization of the common heritage and interests of all engineers.

Engineers' Status in Indiana

MANY readers will remember having filled out, several months ago, a questionnaire prepared by the Bureau of Labor Statistics of the U. S. Department of Labor for a survey of the engineering profession, covering facts on employment and income, and designed to throw light on the incidence of the depression on members of the profession. The first intimation of what the results might be was divulged at the meeting of the American Engineering Council by Isador Lubin, Commissioner of Labor Statistics, who presented some of the statistics for the State of Indiana, the only state for which figures are as yet available.

Although it was expected that complete results would be available earlier than this, no less than eight other surveys, most of them involving much more work, have since been undertaken by the Bureau, and because of the nature of the agencies which they are to serve, have been given priority. But the few facts on the engineer's status in Indiana are of interest, even though they may not be typical of other states or the country as a whole.

That frequently made assertion that great numbers of men educated as engineers find employment in other lines of work is not borne out by the Indiana results, which show that men tend to stay in the fields of their specialty. A trend was noted toward a smaller percentage of engineers in private employment and a greater percentage in government positions, particularly in the service of the state. Practically no change was noted in the percentage of men in the teaching profession. The trend, in five years, from engineering to nonengineering, particularly in the case of young graduates, was expected.

In so far as the relation of education to salaries is concerned it was shown that there was a substantial decrease in earnings from 1929 to 1932, and, for college graduates, an increase, though not to 1929 levels, from 1932 to 1934. Nongraduates suffered similar decreases in earnings, but have not experienced the same recovery.

As to functions performed, one-quarter of the Indiana engineers replying to this question of the survey were in design, another quarter in construction, although not all were in the construction industry, and slightly less than one-third were in operation. Nine out of ten got their jobs as a result of personal contacts.

Few engineers in Indiana are engaged under long-time contracts, and contracts with "separation" clauses are relatively unimportant. As to pensions, 80 per cent enjoy no pension rights, but of those who do, half are on a contributory basis.

These sketchily presented results, representing one state only, are just enough to whet the interest in the complete details and to suggest numerous facts of use to engineers, individually and collectively, in planning careers and programs for the benefit of the profession.

News of A.S.M.E. Affairs

A COMMON source of misunderstanding in all society work is lack of knowledge of what is going on, what plans are contemplated, and what results have been achieved. In a national society with membership running into the thousands the problem of keeping members posted is a serious one and requires reciprocal effort. Officers and staff must find ways of disseminating news of society affairs; members must accustom themselves to the channels through which it is sent to them.

With the exception of certain types of society news that, for one reason or another, are sent out in the form of letters to the individual members, most information must be made public through official publications. In The American Society of Mechanical Engineers MECHANICAL ENGINEERING is the medium through which the members are apprised of "what's going on," and this familiar catch-phrase has, for several years, been the name of the news department of this magazine.

"What's Going On" will be found in the final text pages of every issue of MECHANICAL ENGINEERING. Except for the fact that the Society's interests make it desirable to include somewhere in its monthly journal items that are not strictly confined to the Society's activities, this department might be called "A.S.M.E. News," or "Society Affairs." The more general title does not exclude important releases, such as news of the E.C.P.D., of the American Engineering Council, and of other related organizations in which A.S.M.E. members have interests.

Because from time to time A.S.M.E. members plead ignorance of what's going on after announcements and reports have been published by the Society, attention is called to this news section of MECHANICAL ENGINEERING. Members of the Society should turn to it every month in order to keep in touch with Society affairs, for until the Council has the necessary funds to set up an independent house organ, there exists no other convenient means of distributing A.S.M.E. news. Regular reading of this department will save many misunderstandings.

JAMES WATT, 1736-1819

By GEO. A. ORROK

CONSULTING ENGINEER, NEW YORK, N. Y.

IT IS difficult for modern Americans to picture to themselves the state of society and the arts in Great Britain in 1736. Pepys and Evelyn have painted intimate pictures of the state of the country from the Restoration to the flight of James. Macaulay, in his famous "third chapter," has shown us the country and the people in 1700, while Trevelyan ably covers the period of the third George, the first English Hanoverian king, in which our interest today is centered.

The population of Britain at the time of the Act of Union was small, not exceeding 5,500,000, but many changes in British life and industry had begun and grew rapidly, introducing an entirely new phase into the life and activities of the people. The change from adventure trading to corporation trading, the shifting of the banking business from the Goldsmiths' Guild to the newly chartered Bank of England, the institution of the National Debt, the formation of the East India Company and other trading companies, the reinvention by Abraham Darby of the use of mineral fuel instead of charcoal in the manufacture of iron, and the gathering of the home industries into factories were all signs of a changed social and industrial order. Bridgewater, Brindley, and others were planning and building canals, and a real road-making campaign was being instituted. Despite foreign wars and the panic of 1720, the population increased steadily, and it was in the breathing spell between the last Stuart and the first English Hanoverian sovereign that James Watt was born in Greenock, Renfrewshire, near Glasgow, two hundred years ago.

George III was born in 1738, two years after James Watt, and came to the throne in 1760 when Watt was 25 years old. In the first six decades of the eighteenth century only about 1,500,000 people had been added to the population, but the 7,000,000 of 1760 were to become 14,000,000 by the time the work of these two men was finished and Britain had been remade. In the words of Trevelyan, "With iron and machines was born a new class, the modern mechanic." And as the last Stuarts and the Hanoverian kings saw the influence of parliamentary government steadily grow and the influence of kings decline, so iron and power to drive machines made possible the modern mechanical world with its higher standard of living and its greater comforts and possibilities for the individual mechanic.

The grandfather of James, Thomas Watt, listed as a "mathematician" and "teacher of navigation," had come to Greenock from Aberdeen. Thomas' second son, James Watt, born in 1698, a ship carpenter, chandler, and merchant, married in 1729 Agnes Muirhead, a woman of superior intellect and force of character, and to them was born Jamie Watt, whose birthday we are celebrating today. It is reported that he was delicate, but it is certain that in the face of the cold and wet Clydeside winters he managed to grow to manhood without serious illness and to absorb what knowledge he was able to get from his mother and father, his schoolmasters, and his fellows in the busy trading town of Greenock, which was the Clyde port at that time and one of the chief centers of the tobacco trade.

WEDGEWOOD REPLICA OF CHANTRY BUST OF WATT

(Presented to A.S.M.E. by Erwin Graves, 1892.)

WATT, THE MECHANIC

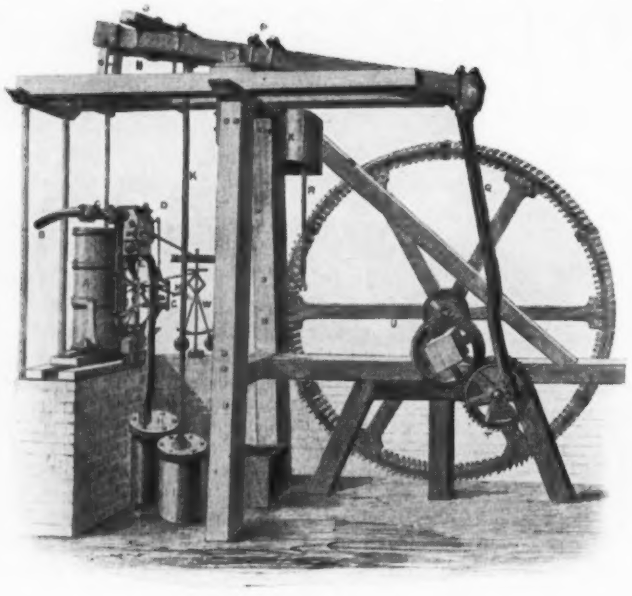
With this mechanical ancestry it was only natural that Jamie Watt should take to tools and want to make things, and very early he had a workroom and forge in a corner of his father's shop where he did those parts of the shipwright's work that could be done at the bench. George Williamson, who left for us the account of Watt's early years, says he became quite expert in so many lines that his shopmates had a saying that "Jamie has a fortune in his fingers." Among his other successes was a model of the crane, which had just been built for unloading the tobacco ships at Greenock, and a barrel organ.

His mother died in his eighteenth year, a great loss to him, for they were most sympathetic, and shortly after he visited his mother's brother in Glasgow, then a quiet university town. He worked there with an optician for nearly a year, and when he was nineteen his uncle advised him to go to London to learn the trade of a mathematical-instrument maker. In London, after much difficulty, he induced John Morgan, who had a shop in Cheapside, to take him on as a journeyman, paying Morgan £20 for the privilege. In a year he learned all that the Morgan shop could teach him, and in 1756, when he was 20 years old, he returned to Glasgow and set up as an instrument maker. The University gave him quarters in the quadrangle, a not unusual practice, and here he came into contact with Dr. Dick, Dr. Joseph Black, Dr. Roebuck, and a young graduate, John Robison, who became his lifelong friends.

WATT, THE EXPERIMENTER

It was here at the University that he started his work repairing the philosophical instruments of the department of natural philosophy. He continued his experiments on all sorts of things, including work on the pressure and temperature of water, which led to his trying high-pressure work with a Papin

An address delivered at the Bicentenary of Watt, Lehigh University, Bethlehem, Pa., January 20, 1936, under the auspices of the University, The Franklin Institute of Pennsylvania, the North American Branch of The Newcomen Society of England, and The American Society of Mechanical Engineers.



WATT'S FIRST ROTARY ENGINE

(*A*, steam cylinder; *B*, steam pipe; *C*, throttle valve; *D*, steam valve; *E*, eduction valve; *F*, eduction pipe; *G*, valve gearing; *H*, condenser; *I*, air pump; *K*, air-pump rod; *L*, foot valve; *M*, hand-gear tappet rod; *N*, parallel motion; *O*, balance weight; *P*, rocking beam; *Q*, connecting rod; *R*, feed pump rod; *S*, sunwheel; *T*, planet wheel; *U*, flywheel; *W*, governor; *X*, feedwater cistern. Illustration is from Smiles's "Lives of Engineers.")

digester. This he finally threw aside because of the explosion hazard. In 1759, he went into partnership with John Craig in the mathematical-instrument business and opened a shop in the Saltmarket, St. Andrew's Street. He did more or less manufacturing, and, among other things, made reed organs.

In 1763 he bought an interest in the Delftfield Pottery Company which made a good grade of white stoneware. He kept his connection with this pottery company for many years, experimenting on kaolin, on furnaces, and in other cognate lines. Later, Dr. Black and Dr. Roebuck interested him in an alkali manufacturing scheme, and he made for them many experiments covering the process. In July, 1764, he married his cousin Margaret Miller, with whom he led a happy life for nine years. Four children were born to her during those years.

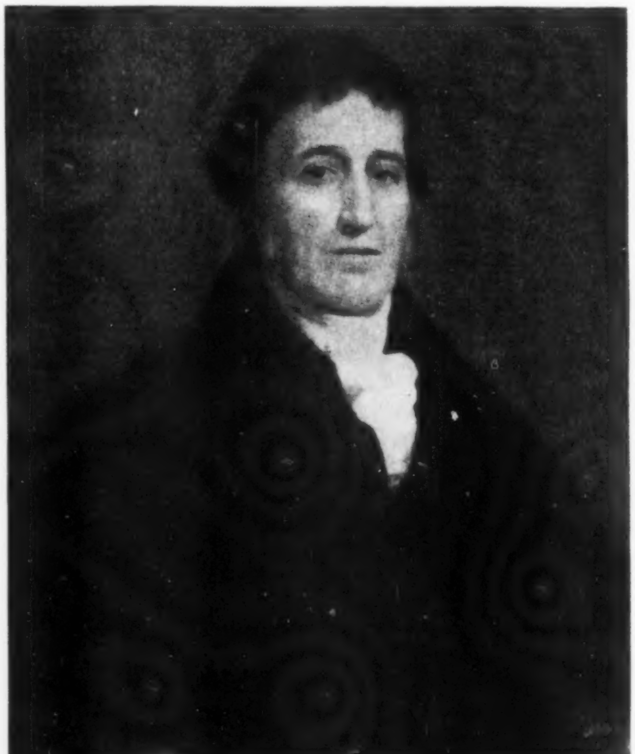
WATT, THE CIVIL ENGINEER

In 1765 he invented a perspective drawing machine which had a wide circulation, as the machine was a really good one and the price was reasonable. Prof. John Anderson in this year commissioned him to repair the Newcomen engine model owned by the University. Watt had made many experiments on boiling water and steam and particularly on the temperature of water boiling under pressure. He learned from Dr. Black about latent heat, and measured the expansive force of steam, and in May, 1765, he had solved the problem of the Newcomen engine. His solution consisted in separating the condenser from the cylinder. The invention of the steam jacket and separate condenser kept the cylinder hot and the condenser cold. The experimental apparatus is to be seen in the South Kensington Museum. The first condenser was of the jet type, but in other experiments Watt invented the surface condenser, and he also closed the top of the cylinder and applied the stuffing box, making the engine double acting.

These experiments took the better part of two years. During this time his partner, John Craig, died, and financial difficulties caused Watt to borrow the funds from his good friend and adviser, Dr. Black, to carry on his steam experiments. The loss of his partner, Craig, and the consequent withdrawal of his capital, made it necessary for Watt to seek additional income, and this he found by setting up as a surveyor. In 1766, with Roger Mackell, he contracted to survey a canal from the Firth of Forth to the Firth of Clyde. This work was completed and the report was printed in 1767, and Watt went to London to see the bill through Parliament. On his return he visited the Bridgewater and Calder Canals. As the winter was a slack time in the canal business, Watt turned back to the engine, and his experiments so impressed Dr. Roebuck that Roebuck agreed to pay Watt's indebtedness to Dr. Black, the cost of the patents, and to become a partner with Watt, taking a two-thirds interest in his engine experiments; so Watt in July, 1768, went to London, and on August 9 took oath on his first steam-engine patent embodying the separate condenser.

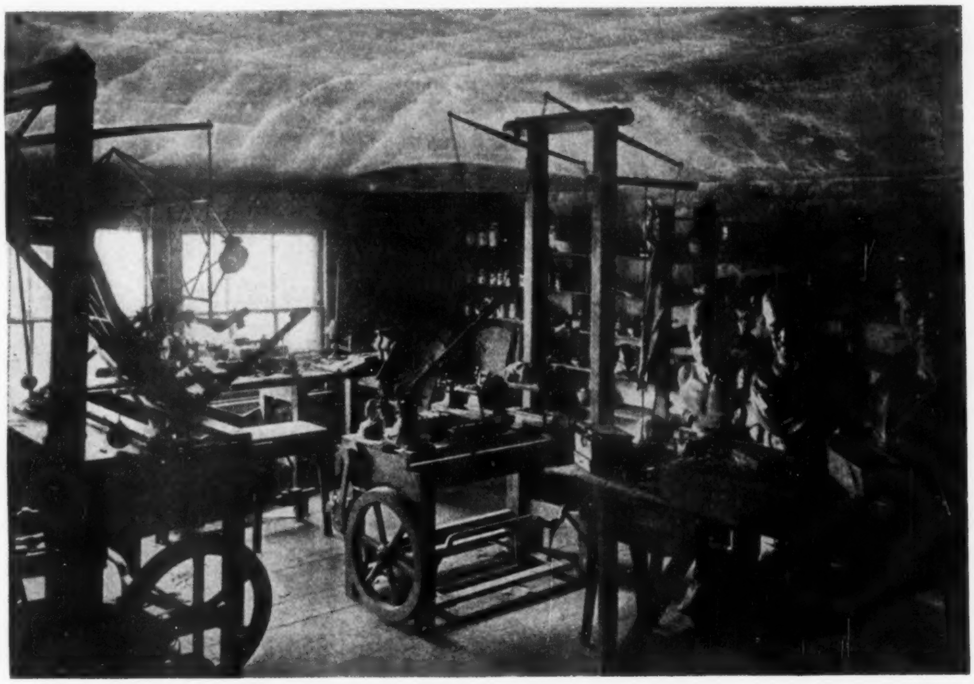
On his way back to Glasgow he stopped at Birmingham and stayed for two weeks with Matthew Boulton. The two became very good friends, for, although they were opposite in character, they were sympathetic in many of their ideas and ideals. Watt told Boulton most of his hopes for the engine; and as Boulton became equally enthusiastic and offered to buy in to the partnership, Watt agreed to put the proposition up to Dr. Roebuck. On arriving home, Watt started work on an 18 in. by 6 ft inverted cylinder to prove his engine patents. This engine was erected at Kinneil after a considerable delay. Roebuck's offer to Boulton was only a license for the Midland counties, which interested Boulton not at all, so the matter was dropped for the time.

It was about this time that Watt invented a method of stadia surveying which was to be of great use in his work later on.



WILLIAM MURDOCK

(From an Oil Painting by Graham Gilbert at the Birmingham Art Gallery.)



WATT'S GARRET WORKSHOP AT HEATHFIELD

His engine experiments, which he carried on between surveys, included a tubular surface condenser with two air pumps. His work on the engine was stopped for a while by a survey of the Firth of Clyde for the City of Glasgow, which contemplated getting sufficient water to accommodate ships of some size. He also surveyed a route for the Lanarkshire Canal from the coal fields to the City of Glasgow, from which company he drew 200 pounds per year as chief engineer until 1772. The survey for the Strathmore Canal was put through at this time.

Then came plans for docks and harbors at Port Glasgow, the Canal at Crinan, and the one at Tarbet. In 1772 he was commissioned to survey a water supply for Greenock, and he built two reservoirs for the city, one of which is still in use. In 1773 he made surveys for five shorter canals and also started the survey for a canal between Inverness and Fort William, now the Caledonian Canal, on which his stadia method was used. About this time he used a screw to control a dividing engine for making scales.

BOULTON ENTERS THE PICTURE

During 1772–1773 a financial panic swept over Britain and Watt's partner, Roebuck, who was concerned with iron works in Stirlingshire and other chemical works in the Black country, had to go into bankruptcy and his property was taken over by creditors. The creditors, however, placed little or no value on the engine at Kinneil, and in July, 1773, Boulton bought out the two-thirds partnership from Roebuck's creditors, thus becoming Watt's partner. About this time also, Watt was called home from his canal work by the sickness of his wife, only to find on his arrival in Glasgow that she had died the day before.

His discouragement following the violent uprooting of his home made him ready to drop everything and join Boulton in Birmingham, but the Caledonian Canal report had to be finished and a survey of the Upper Forth needed completion, all of which work he finished by May, 1774, when he left Glasgow with his family for Birmingham, which was to be his home for the remainder of his life.

Watt was now in his thirty-ninth year and his struggles were at an end. He had been a timid and rather sickly boy who had feared the fight for a place in the world and so he had kept himself more or less cloistered in the University. He was, by dire necessity, dragged out of this sheltered field to undertake the civil-engineering work on the canals which had been his main source of income for six years, but he hated business and bargaining. He did not enjoy commanding men and his best work was done as an experimenter, working alone where he could give all of his mind to the subject in question. He now had in Matthew Boulton an efficient business partner, who was a financier as well as a manufacturer and who had faith in what Watt could do and in the future of his inventions.

We have many examples of men who experimented and embodied the results of their labors in a machine. We may recall Worcester, Savery, Papin, whose digester was used by Watt, Dud Dudley, and the Darbys, all of whom experimented to a greater or less extent on their inventions. Watt's friend, Dr. Joseph Black, experimented to a degree, but we also remember the Royal Society arguments about the brimming pail of water and the live fish. It was after years of Aristotelian reasoning that some unknown doubter suggested that the experiment be tried, settling the controversy forever. Watt was an experimenter. Starting with models, then quantitative as well as qualitative trials of materials, and of chemical, and physical changes, and, eventually broadening to a very wide field indeed, he was one of the first, if not the first, example of Trevelyan's new class, the modern mechanic.

"THE MODERN MECHANIC" AS WELL AS THE ENGINEER

But he was even more than a mechanic. His incursions into optics, physics, chemistry, and above all his passion for measuring results with accuracy, set him apart from the other inventors of the time who perhaps were content with qualitative results alone. He commenced to make accurate engine tests in 1774, and his notebooks show he kept this up until he retired from the engine business. His civil-engineering work also betrays this love for accuracy, and it is known that Telford in

later years finished the Caledonian Canal with only minor changes from Watt's plan.

Watt's fertility in expedient, never shown so well as in little things like the dividing machine or the parallel motion, blossomed under the university environment and the encouragement of good friends like Black, Robison, Boulton, and Small.

He did not readily collect and use assistants and understudies, probably because he had the urge to feel with his own hands the actual thing he was thinking about, and many good leads were left unraveled becaused of the lack of time, health, and the necessity for earning a living. Organized research with trained assistants was to come later.

Watt's civil-engineering work is not so generally known, but its quality was so good that there is little doubt he would have taken a high rank in the profession if his early love, the steam engine, and his friend Boulton had not effectually prevented its continuance.

BOULTON AND WATT

Watt, with what was left of his family, his sister and two children, and his tools and belongings arrived in Birmingham on June 1, 1774, where he immediately proceeded to set up the Kinneil engine, with its block-tin cylinder, in a corner of Boulton's shop. And here he threw himself into the solving of his worst trouble, the piston packing. He tried many things from pasteboard to metallic packing. The block-tin cylinder collapsed and was replaced by an iron cylinder furnished by Wilkinson who had just invented the boring bar and could furnish a truly cylindrical cylinder which greatly helped the solution of the packing difficulty. His other trouble was the patent situation. The partners determined to try to secure an extension of the original patent rather than to risk taking out a new one. After much trouble and appearances before Parliament, on May 22, 1775, the patent of 1768 was extended for 25 years and was made to cover Scotland as well as England.

Shortly afterward, on June 1, 1775, Boulton and Watt entered into the famous partnership agreement that was to last till the expiration of the patent. By its terms Boulton was to assume all past obligations, furnish all moneys, and keep the books, taking a two-thirds' interest in the profits. Watt was to furnish all drawings, give directions, and make surveys for which his remuneration was to be £300 per year. It is doubtful that the papers were ever drawn up and executed, but that did not matter with two such men as Watt and Boulton.

The firm was now in working order and the two first engines were a 50-in. cylinder pumping engine and a 38-in. diameter blowing engine, which were rapidly put through the shops and erected. These engines were started about March, 1776, and were satisfactory, despite troubles with packing. In the summer Watt revisited Glasgow and married his second wife, Ann MacGregor. His notebook contains this entry: "I consider this as one of the wisest of my actions."

THE ROTATING ENGINE

The Cornish orders now began coming in and for the next five years the works were busy with pumping engines for dewatering the deep Cornish mines. Watt spent much of his time in Cornwall, having a house at Redruth. In 1777, Boulton hired Murdock to aid Watt as draftsman and later in erecting and testing. It is said that Boulton hired him because of an oval wooden hat Murdock had turned out on a lathe of his own construction. Murdock proved to be a very valuable man indeed as he later became a partner in the firm. By 1780, the partners saw light and were able to show profits which increased as the years went by.

The pumping-engine market continued, but the partners had been considering entering the millwork field and competing with the water wheels and "horsepowers." In 1780, the actual work on this type of engine was started. Watt did not believe the crank was patentable, but Pickard had secured a patent on a crank in combination with a wheel and bob weights in 1780. So Watt in 1781 patented five ways of securing rotative motion from reciprocating motion, among them the sun and planet gears, the only one of the five that was actually used. Engines with this type of crank followed each other in rapid succession. In 1782 Southern was hired as Watt's assistant and draftsman. He proved to be as much of an acquisition as Murdock and later he also was admitted into the famous partnership.

In the 1782 patent Watt had included expansive working and the double-acting engine and these improvements necessitated some means of guiding the piston-rod head which had been hung from the beam end sector by a chain. To end this trouble he invented the parallel motion which he fancied more than any other of his inventions. With the pantagraph which completed it, it was a beautiful invention and was patented in 1784.

Mention must be made of the Albion Mills engines for the steam flour mill for which the firm took the contract for supplying the machinery and for which John Rennie undertook the erection. These engines were very successful and the mill worked well for three years, when it was destroyed by fire. In 1788 the application of the governor was patented and 1794 saw the invention of the indicator. Mention should also be made of the copying press, an invention which was made about 1778 and has been in use until the invention of typewriter carbons put letter-press copying into the background. The Pickard-crank patent expired in 1794, and all of Boulton and Watt's later engines used this device.

WATT'S RETIREMENT—HIS INFLUENCE

In 1799 Watt retired to his estate at Heathfield and the summer estate at Doldowlod on the Wye in Radnor, Wales, where he lived the life of a country gentleman. He and his wife traveled to some extent on the Continent and revisited Cornwall and Scotland. He made many new friends and retained his interest in science and art but avoided ostentation. He received the honorary degree of doctor of laws from the University of Glasgow, but refused a baronetcy and election as high sheriff of the counties of Stafford and Radnor.

In his later years Watt was afraid of losing his mental powers, and therefore took up the study of languages again, with great success, to make sure his brain was working. He was greatly pleased when in 1810 (75 years old) his plan for a flexible water pipe under the Clyde was accepted by the Glasgow Water Works. He would take no fee but was presented with a silver service by the corporation.

Watt had a workshop in an attic room at Heathfield where he continued to work and use his active mind in all sorts of experiments. When Heathfield was torn down this room was set up, exactly as it was at Watt's death, in the South Kensington Museum, where modern generations may see his last works, the tools with which he worked, and the surroundings. The parallel motion still lingered in his mind, and a survival of the perspective-drawing machine as well, for he was at work during the last years of his life on a pantagraph device for copying medals and sculpture. The tools in their drawers, chemicals in jars, jigs and models are reposing in their ordered disorder just as he left them.

It is given to but few individuals to be of great use to their fellowmen and among these few Watt takes high rank. His use of the experimental method, his urge for accuracy, his wide

curiosity which led him into all sorts of problems, and his inventive genius all combined to overcome the defects of ill health, lack of perspective, and the difficulties of earning a living in the epoch of great changes in which he lived and for which he was partly responsible.

Pessimistic to the extreme in his earlier years, he mellowed with age and the improvement of his finances. He made friends easily and kept them. Diffident and unostentatious, widely interested in a great variety of subjects, he conducted an increasing correspondence and contrived to avoid entanglements in the political field so attractive to many at that time.

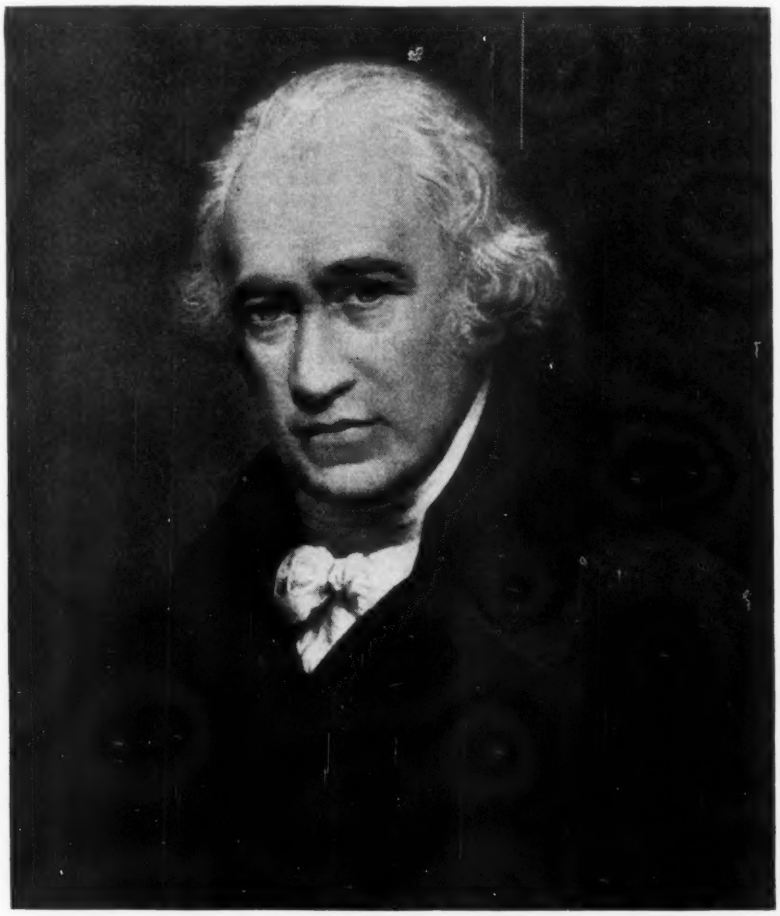
Living as long as he did he had the disadvantage of seeing his good friends pass away one by one, but while regretting their passing he became more interested in the doings of the younger generation.

It is difficult to rank his inventions. He himself fancied the parallel motion. I am inclined to believe the recognition of the expansive force of steam was the high point of his endeavors, and this was followed closely by the separate condenser and the stadia method of surveying. His work in the pottery field was sound but not spectacular, and the friendship with Wedgewood was a proof of good work in ceramics.

I have said little of the litigation made necessary by the patent monopoly but from 1782 to 1799 a large portion of Watt's time was taken up with this protection of the partnership rights.

He died at his home, at Heathfield, on August 12, 1819, in his eighty-fourth year, after a short illness. He was buried in the Handsworth Parish Church beside his friend and partner Matthew Boulton. His fame as an inventor and scientist continued to increase and receive public recognition. A statue by Chantry, paid for by public subscription, was set up in Westminster Abbey in 1824, and I cannot better close this appreciation than by quoting the inscription on the base of the statue, written by Lord Brougham, and said to be the finest lapidary inscription in the English language:

Not to Perpetuate a Name
Which Must Endure While the Peaceful Arts Flourish
But to Show
That Mankind Have Learned to Honour Those
Who Best Deserve Their Gratitude,
THE KING,
His Ministers, and Many of The Nobles and Commoners of The Realm,
Raised This Monument to
JAMES WATT,
Who, Directing The Force of An Original Genius,
Early Exercised In Philosophic Research,
To The Improvement of
THE STEAM-ENGINE,
Enlarged The Resources Of His Country, Increased The Power Of Man,
And Rose To An Eminent Place
Among The Most Illustrious Followers of Science
and The Real Benefactors Of The World.
Born at Greenock, MDCCXXXVI.
DIED At Heathfield, In Staffordshire, MDCCCXIX.



JAMES WATT AT THE AGE OF 71 FROM THE ORIGINAL PAINTING BY PARTRIDGE BELONGING TO THE ESTATE OF JOHN SCOTT, ESQ., OF HAWKHILL, GREENOCK

(From a photograph in the files of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.)

MATTHEW BOULTON
(From the Beechy portrait.)

MATTHEW BOULTON, 1728-1809

By JOSEPH W. ROE

NEW YORK UNIVERSITY, NEW YORK, N. Y.

FORTUNE smiled twice on James Watt. The first time was on that famous Sunday afternoon walk in the spring of 1765 on Glasgow Green, when the idea of a separate condenser came to him. As Watt himself said, "When once the idea of separate condensation was started, all the improvements followed as corollaries in quick succession; so that in the course of one or two days the invention was thus far complete in my mind." This started the long series of inventions which mark Watt as one of the greatest of inventors.

The second smile came when the famous partnership with Matthew Boulton began. We have only to follow Watt's early struggles to see what this meant to him. Watt was an instrument maker, and in a few days had made a model which demonstrated the soundness of his invention, but when he tried to build an engine "in great" he met only a succession of failures; he could not make it a commercial success. For nine long years he struggled on with uncertain and inadequate backing. He patented the invention in 1769, but within a few years the engine had both literally and figuratively come to a standstill. To support himself he became a civil engineer and surveyor, worked on plans for the Port of Glasgow, designed bridges, and surveyed the Caledonian and other canals; but he made only a bare living and sank deeper and deeper into discouragement and debt.

Then came Boulton. Watt first met him in 1768, through Dr. Small, who himself was introduced to Boulton by Benjamin Franklin. For several years Watt and his partner, Roebuck, tried to interest Boulton in joining them in the development of the engine, but they were unsuccessful. Finally Roebuck became insolvent, and Boulton, who had loaned him money, took over his two-thirds ownership in the patent in discharge of the obligation and joined Watt as a partner.

Matthew Boulton was the son of a Birmingham manufacturer of the same name. At seventeen he invented an inlaid steel buckle which became the fashion and was a great success. His father took him into full partnership at 21; and in 1759, when he was only 31, he succeeded to the entire business at his father's death.

Under Matthew Boulton's management the business grew rapidly and the plant was moved from the city to Soho, then only bare fields, two miles north of the town. Here was built one of the first real factories, a long, three-story building,

An address delivered at the Bicentenary of James Watt, Lehigh University, Bethlehem, Pa., January 20, 1936, under the auspices of the University, The Franklin Institute of Pennsylvania, The North American Branch of the Newcomen Society of England, and The American Society of Mechanical Engineers.

Illustrations are from Smiles's "Lives of the Engineers," unless otherwise noted.

which was added to repeatedly until it housed more than a thousand workers. It was the most highly developed manufacturing plant in England, and that probably meant the whole world. It became one of the show places in England, with an influence not unlike that of the Colt Armory later at Hartford, or the Ford plant today. Here Boulton made all kinds of artistic hardware and metalwork. Distinguished people from all over Europe, from the Empress Catherine and the Queen of England down, visited it. The business rose in four years from £7000 to £30,000 a year. Boulton made systematic and extensive use of machinery, division of labor, and many of the elements of modern scientific management, such as piecework, a profit-sharing bonus system, and a mutual-benefit insurance society.

BOULTON AN EXTRAORDINARY BUSINESS MAN AND MANUFACTURER

Matthew Boulton was an amazing man, courageous, almost unerring in judgment, with tremendous vitality of mind and body, buoyant and generous. He was more than a man of business; he was a man of culture and an intimate friend of the foremost people of his generation. He had marvelous tact in every relationship. He could meet kings with square-shouldered self-respect but unerring courtesy, or deal with drunken workmen with patience and understanding and get the very best out of them, where Watt threw up his hands in despair. He had ample capital, wide business contacts, and tireless energy. As Smiles says, "Had Watt searched Europe through, he could not have found a man better fitted than Matthew Boulton was for bringing his invention fairly before the world."

This was the man whom fortune linked to Watt, who was poor, who hated business, who was timid, easily discouraged, and half an invalid, but who was an inventive genius of highest order. Could there have been a more marvelous combination?

The partnership papers were not elaborate and were practically a copy of a letter of Watt to Boulton on July 5, 1775. By these Boulton was to have a two-thirds interest, pay the legal expenses outstanding, advance stock in trade, and keep the books. Watt was to have a one-third interest and was to make the drawings and provide supervision. The partnership was to run for 25 years from June 1, 1775. This was the term covered by the Act of Parliament extending the Watt patent, and the two partners did retire from the business at the expiration of the patent in 1800. It was one of the most momentous partnerships in history.

Boulton, an experienced manufacturer, realized what was involved in launching such an enterprise and knew that Watt's patent of 1769 would be running out by the time the engine had become a demonstrated success. His first move, therefore, was to secure, in 1775, an extension of the patent for 25 years by the Act of Parliament just referred to.

Watt moved to Soho, and work was begun. One of the difficulties which had dogged Watt all along was "villainous bad workmanship," particularly in the boring of his steam cylinders. Smeaton, the foremost engineer of the time, had reported to the Society of Engineers regarding Watt's engine that it was correct in principle but that neither the tools nor the workmen existed that could manufacture so complex a machine with sufficient precision. We can realize what it meant to build engines before the day of machine tools when we read that Watt had been trying to work with cylinders three-eighths of an inch out of round. The ingenious parallel motion which he invented later was necessary because there were no planers in existence even then, or for many years thereafter. Even at Soho things were not much better, but in 1775 Boulton wrote to Watt that they were out of their troubles, as Mr. Wilkinson had bored several cylinders "almost without error." One, 57 in. in diameter, was "true within the thickness of an old shilling."

This John Wilkinson is an interesting figure. Except for his tremendous energy and great business ability, he was the antithesis of Boulton and far from lovable. He was dour, hard, and none too scrupulous, but Boulton and Watt worked in close relationship with him for many years. Only Boulton could or would have put up with him. He designed and built the first modern machine tool for heavy metal work, built the first iron bridge, the first iron boat, and ordered and installed for his forge the first steam engine built at Soho. Within a few years he had four such engines at work in the same plant, with license "to erect one at Wilton House, as well as a devil to be erected where he pleases." Apparently, raising the devil is no new thing!

BOULTON A MAN OF VISION AND RESOURCEFULNESS

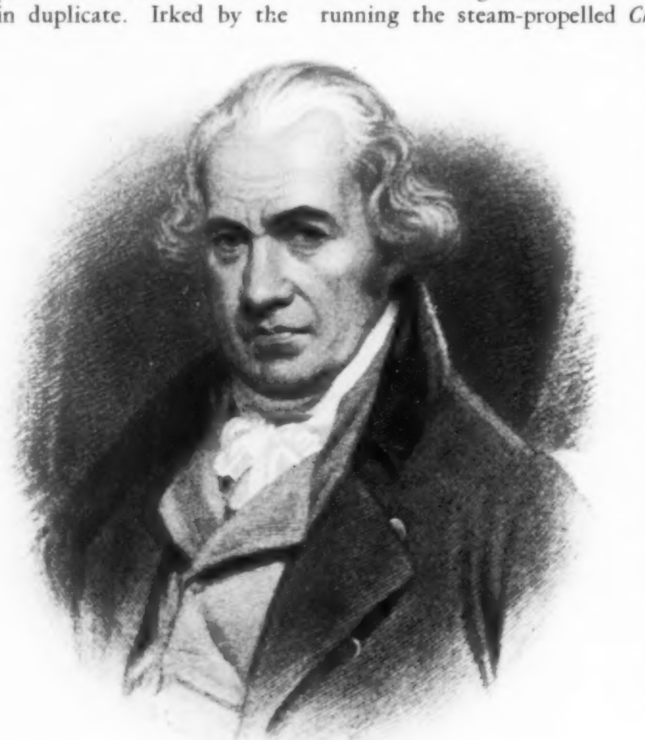
From the start, Boulton had the rotary steam engine in mind, but the first demand for the Watt engines came from the tin mines in Cornwall, which were being drowned out, as the Newcomen engines were no longer able to cope with the water economically. The new Watt engines could do the work on about one-quarter of the fuel, but Boulton and Watt had the greatest difficulty in getting this fact accepted. The first engines, therefore, were sold on a royalty basis, under which Boulton and Watt supplied the materials furnished by them at prime cost, and took their pay for the plans, supervision of construction, and a license, to run during the life of the patent, representing one-third of the share of the annual savings in fuel effected. This system was ingenious, fair, and certain to breed trouble. As the years went by the royalties came to be looked on as a tax, to be evaded on any possible pretext; but it was many years before the terms of sale were based wholly on fixed price.

For several years Watt spent most of his time in Cornwall superintending erection, nursing "lame ducks," and getting new orders, most of the time so utterly discouraged that it took all of Boulton's diplomacy to keep him

SOHO MANUFACTORY

going. One of Watt's letters written at this time about an unexpectedly favorable settlement starts off with "Hallelujah! Hallelujee!" and ends with the postscript "Please burn this nonsense," and is referred to by one of his biographers as the only sanguine letter he ever wrote.

Watt was a voluminous correspondent and for the sake of record he wrote all his letters in duplicate. Irked by the drudgery of this, he invented the letter press in common use in every office for a century. Even down to the days of typewriting, the old screw copying press was as common as the big leather-bound ledgers and the pigeon-hole desk. Watt would have used the idea only for his own convenience, with no realization of its economic value, but Boulton immediately saw its possibilities. It was patented in 1780 and Boulton built 500 presses, went up to London, started in with the King, and came down through the House of Lords, the Commons, the bankers, and the law offices. He encountered opposition and prejudice everywhere, but by the end of the year 150 were sold and the device was started on its long and useful career. The profits of this business carried the engine business over some of its most critical days.



JAMES WATT
(From the Beechy portrait.)

For many years the business of Boulton and Watt was really that of consulting engineering and the collection of licenses for the engines, with manufacturing largely incidental. They furnished the plans, supervised erection, and made and supplied the valves, valve gears, and "nozzles." Wilkinson cast and bored the cylinders, while the foundations and walking beams were supplied by the purchaser or from local sources. There was much friction latent in this situation and finally in 1795 the partners set up their own shop and furnished all the parts themselves. By that time, also, they were in a position to sell the engines outright.

It is strange that with all the creative genius which Watt put into the steam engine he seems to have had so little interest in its possible broader applications. Watt not only made no great contribution to steam transportation, either by land or water, but he seems to have had little interest in it. It was Boulton who had persistently to prod Watt to the full development of the rotary engine. He saw clearly from the start that this would be its major use. Against Watt's advice and urging he pushed the rotary engine and undertook to carry himself the risks involved. When the problem was satisfactorily solved Watt was anything but elated over it, and he doubted for some time "whether it would be worth the while of the Soho firm to accept orders for engines of this sort." It was Boulton's energy and vision which not only guided the fortunes of the firm, but developed the economic possibilities of the steam engine. It was Murdock, his workman, who made the first steam self-propelled model in England, which scared the Redruth parson in 1784 on his evening walk, and Watt advised Murdock to give up his foolish idea. Watt had included the idea of a locomotive engine in his patent in 1784 but never took any steps to put it into execution.

Probably a dozen men were experimenting with the use of steam for navigation before 1800. In 1801 Symington was running the steam-propelled *Charlotte Dundas* on the Clyde. Fulton saw it, rode on it that year, and in 1803 ordered an engine from Boulton and Watt, which was shipped to New York in 1805 and was the one which drove the *Clermont* on its historic trip in 1807. As late as 1812, Watt, writing of the *Clermont*, describes its machinery and says, "A machine of this kind could not pass bridges and locks, which all our navigations are full of; but might navigate in the tideway or the Thames or Severn. . . . On the whole, as far as at present known to me, I think it would not answer the purpose you want." A strange obtuseness; and yet as far back as the 1780's he thought of "a rotary oar," that is, a screw propeller. Perhaps the invention of the reciprocating engine was glory enough for one man.

In the later years of the partnership the firm came out into the sunshine of assured fame and prosperity. From 1775 to 1800 Boulton and Watt erected 289 engines in England alone, as follows:

Years	No.	Total hp	Avg hp
1775–1785	66	1238	18.7
1785–1795	144	2009	14.5
1795–1800	79	1296	16.5
	289	4543	15.7

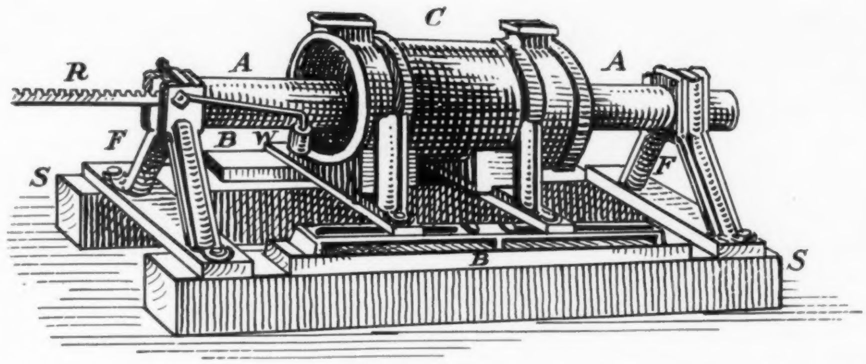
These 289 engines were for the following uses: Cotton mills 84, collieries 30, foundries and forges 28, copper mines 22, canals 18, breweries 17, water works 13, woolen mills 9, and miscellaneous 68.

The list does not include engines sold to other parts of the British Isles or on the Continent, but the number of these was relatively small. Including these the total horsepower represented was about 5000, or a little more. These engines were the source of the mighty river of mechanical power. Today we have single units of more than forty times the capacity of all the engines built by Boulton and Watt during their entire partnership.

BOULTON AND WATT PARTNERSHIP CARRIED ON BY SONS

With the expiration of the patent the two partners retired and the business was taken over by Matthew Robinson Boulton and James Watt, Jr. The two sons handled the business wisely. They developed the enlarged manufacturing business begun in 1795, met the problems arising from the expiration of the patent and termination of royalties, and re-

organized the whole enterprise to meet the new competitive conditions. Erich Roll has written a book[1] in which he says that the career of Boulton and Watt in its second phase under the sons was in many ways as remarkable as it had been in the previous generation. It, of course, did not contribute so much to engineering, but its pioneering work in factory organization and administration was an outstanding example of early industrial method.



SKETCH OF WILKINSON'S BORING MACHINE USED FOR MACHINING CYLINDERS OF WATT'S ENGINE

(On two oaken stringers *SS*, frames *FF* were mounted which carried a hollow boring bar *A* driven from the end. The cylinder to be bored was clamped to saddles as shown. The cutters were carried on a head which rotated with the bar and was fed along it by means of an internal feed-rod and rack. In the machine shown the feeding was done by a weight and lever which actuated a pinion gearing with the rack *R*, but later a positive feed through a train of gears operated by the main boring bar was used.)

Watt lived for twenty years after his retirement, surviving Boulton by ten years, one of the few inventors who came into his own, in far better health than he had ever known in early life, with comfortable means and honored by all. Boulton, unlike Watt, continued his interest in the business, although out of active management, particularly in the development of coining machinery. In the last few years his health became broken and he died in 1809.

Boulton was one of the great business men of all time—one of those who, without being great inventors themselves, make inventions useful to society. They are better than amassers of wealth, they are creators of wealth. Without Boulton Watt's engine would, of course, have ultimately come into use in some other way, but Watt himself would probably, like poor John Fitch, have died a broken-hearted failure.

Boulton had a better idea of the usefulness and possibilities of the steam engine than Watt himself. He believed in it when Watt lost heart. "He was Watt's very backbone. He braved and risked everything to carry the scheme through. He mortgaged his lands to the last farthing; borrowed from his personal friends; raised money by annuities; obtained advances from bankers; and had invested upward of £40,000 in the enterprise before it began to pay."

WATT'S TRIBUTE TO BOULTON

What better or more authoritative tribute could there be than this, written by Watt himself, dated Glasgow, 1809, and found among the Soho papers?

Through the whole of this business Mr. Boulton's active and sanguine disposition served to counterbalance the despondency and diffidence which were natural to me; and every assistance which Soho or Birmingham could afford was procured. Mr. Boulton's amiable and friendly character, together with his fame as an engineer and active manufacturer, procured us many and very active friends in both Houses of Parliament. . . . Suffice it to say, that to his generous patronage, the active part he took in the management of the business, his judicious advice, and his assistance in contriving and arranging many of the applications of the steam-engine to various machines, the public are indebted for a great part of the benefits they now derive from that machine. Without him, or some similar partner (could such a one have been found), the invention could never have been carried by me to the length that it has been.

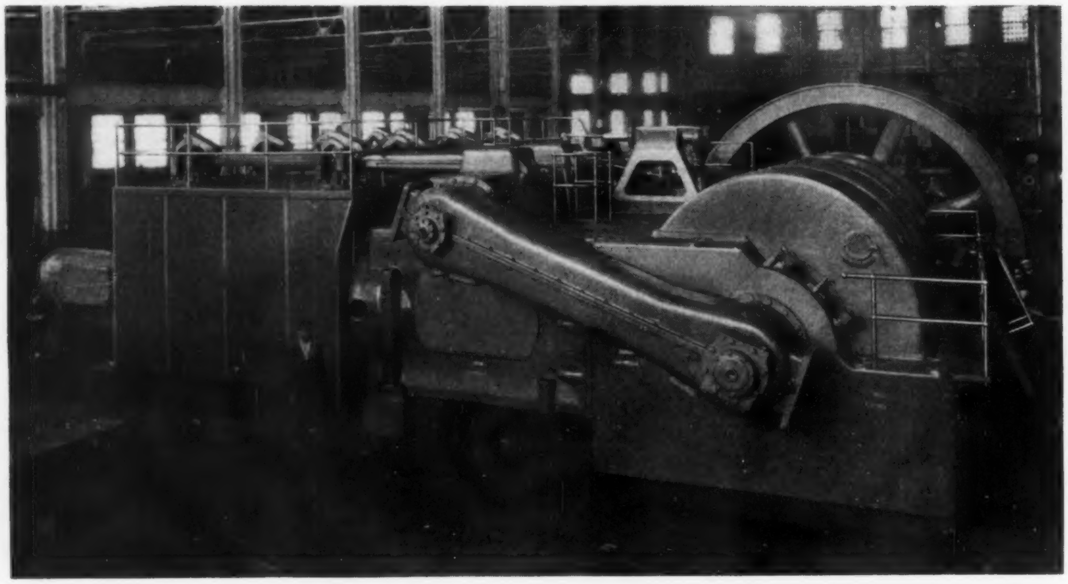
Mr. Boulton was not only an ingenious mechanic, well skilled in all the arts of the Birmingham, manufacturers, but he possessed in a high degree the faculty of rendering any new invention of his own, or of others, useful to the public, by organising and arranging the processes by which it could be carried on, as well as of promoting the sale by his own exertions and those of his numerous friends and correspondents. His conception of the nature of any invention was quick, and he was not less quick in perceiving the uses to which it might be applied, and the profits which might accrue from it. When he took any scheme in hand, he was rapid in executing it, and on those occasions spared neither trouble nor expense. He was a liberal encourager of merit in others, and to him the country is indebted for various improvements which have been brought forward under his auspices. . . .

In respect to myself, I can with great sincerity say that he was a most affectionate and steady friend and patron, with whom, during a close connexion of thirty-five years, I have never had any serious difference.

HANDSWORTH CHURCH, THE BURIAL PLACE OF BOULTON, WATT, AND MURDOCK

The two men lie buried near each other in Handsworth Church, which is as it should be. There can be no full acknowledgment of the world's debt to James Watt which does not include Matthew Boulton.

[1] "An Early Experiment in Industrial Organization," by Erich Roll, Longmans, Green, and Co., New York, 1930.



UNIFLOW ROLLING-MILL ENGINE

(Four-cylinder condensing. At 45 per cent cut-off will develop 14,000 hp and will develop 30,000 hp at maximum. Built by Nordberg Manufacturing Co., for Wheeling Steel Corporation, Stubenville. Courtesy Nordberg Mfg. Co.)

THE STEAM ENGINE *in the* NINETEENTH CENTURY

By DEXTER S. KIMBALL

CORNELL UNIVERSITY, ITHACA, N. Y.

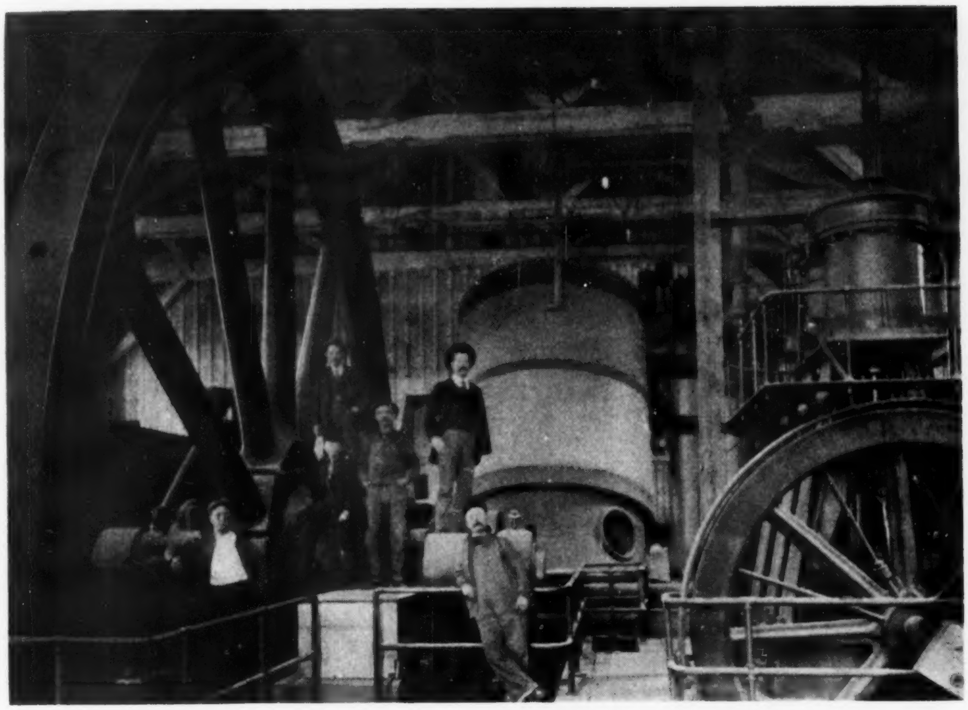
THE steam engine as conceived by its inventor and his contemporaries was, of course, a rather crude machine, but even before Watt's passing it had been applied successfully to a variety of purposes, such as pumping and driving mill machinery, and engineers and inventors were busy trying to adapt it to the problems of transportation both on land and water. It was soon seen that the original *form* of the engine was not naturally suited to all purposes, and the first fifty years of the last century was a period of experimentation, adaptation, and elimination, out of which has come a few well-recognized types of engines and a few valves, valve gears, and other auxiliary devices, the combinations varying in different lines of work. The various forms of governors, slide valves, Corliss valves, and link motions are all survivals of the fittest from fifty years of experimentation. Dr. Thurston remarks: "By the middle of the present [nineteenth] century, the steam engine had been applied and successfully to every great purpose for which it is fitted. Its first application was to the elevation of water; it next was applied to the driving of mills and machinery; and it finally became the great propelling power in transportation by land and sea." By the end of the nineteenth century it had reached its maximum of size and efficiency and with the appearance of the steam turbine and the internal-combustion engine its place in industry has been challenged. It may be helpful in visualizing its growth to follow its rise in a few of its major applications.

MINE PUMPING

One of the first applications was to mine pumping, and out of this came the Cornish pump. In this pump a heavy pump rod is suspended from a "bob" or rocker, the rod carrying vertical plunger pumps at convenient intervals; in deep mining about 300 ft apart. The engine lifts the rod by oscillating the bob and the weight of the rod is sufficient to perform the pumping. In the Watt engine the beam itself acted as a bob. This simple and effective device was imported into this country and was developed to a remarkable degree in the deep mines of the Comstock Lode at Virginia City. The accompanying illustration shows such an engine developed as these shafts sank to a maximum depth of about 3000 ft.

In the early pumps the bob was driven by a small engine geared to the driving mechanism, but as greater depths were reached large compound horizontal or vertical engines were connected directly to the pump bob. These engines were of two distinct types. In one no flywheel was used but an elaborate "Davy differential" valve gear insured that the pistons followed full stroke. In other engines a flywheel

An address delivered at the Bicentenary of James Watt, Lehigh University, Bethlehem, Pa., January 20, 1936, under the auspices of the University, The Franklin Institute of Pennsylvania, The North American Branch of the Newcomen Society of England, and The American Society of Mechanical Engineers.



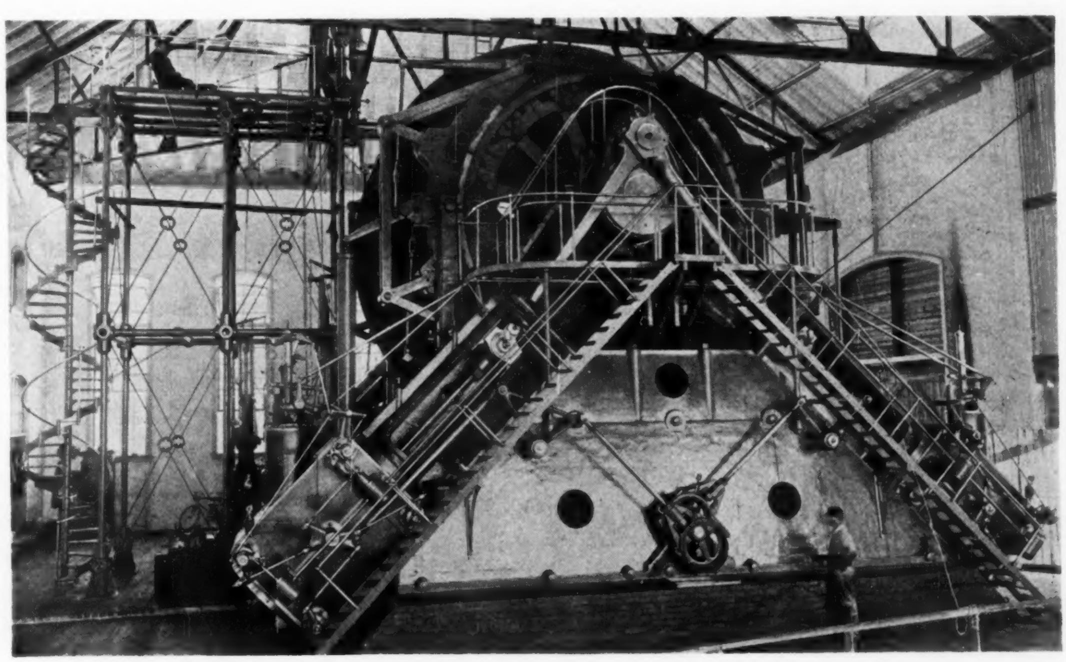
CORNISH PUMPING ENGINE OF UNION MINE, VIRGINIA CITY
(Cylinders 61 × 81 in. and 100 × 99 in., noncondensing.)

attached by crank and connecting rod to the bob insured continuity of action and full stroke. A number of these Comstock pumps attained great size. Thus the pump at the Union shaft, an illustration of which is shown, was operated by a flywheel engine with compound noncondensing cylinder 64 by 81 in. and 100 by 99 in., coupled directly to the bob. The pump rod was of Oregon fir, 16 in. square, spliced at the joints, and reinforced with heavy wrought-iron straps throughout its length. The rod operated a double line of plunger pumps 15 in. in diameter with a 7 ft 6 in. stroke, making about six strokes a minute. This pump was erected some time in the 1880's and it represents the limit of pumping by the Cornish system. It is to be regretted that lack of space prevents a description of the pumping engine as developed for municipal and industrial pumping.

MINE HOISTING

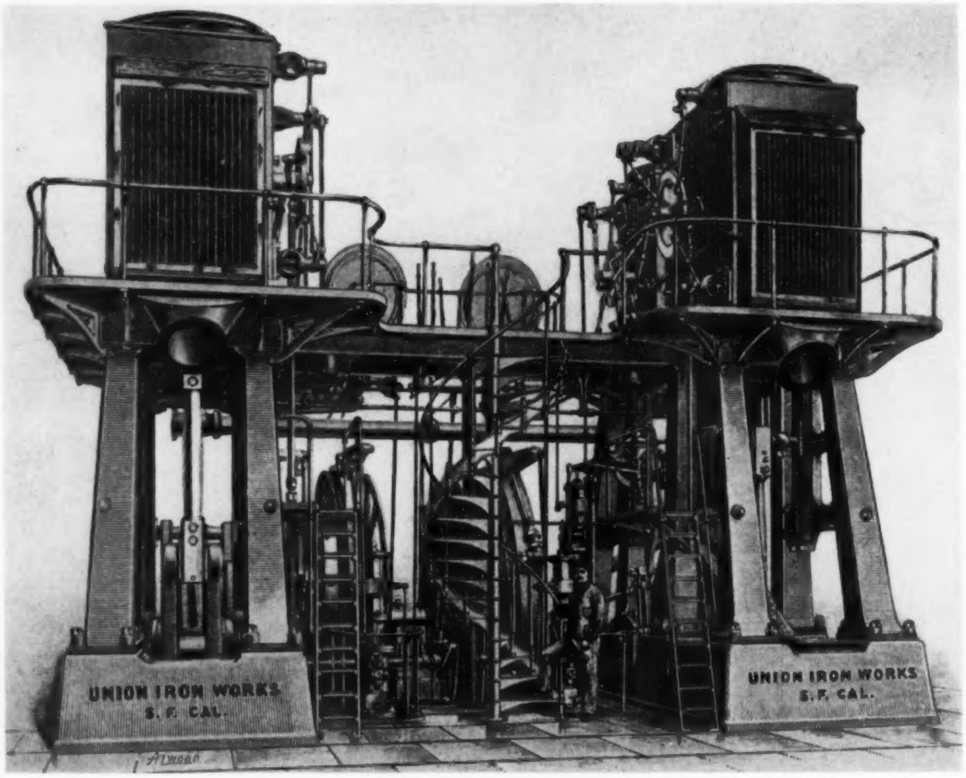
Another early application of the steam engine was to mine hoisting. All are familiar with the small geared hoist to be seen wherever weights of moderate size are to be handled through moderate distances. But the steam hoisting engine has attained its greatest size and efficiency in deep-mine work. Up to moderate depth (1200 ft) the geared hoist is quite satisfactory and the illustrations show a few examples of this type. In most cases of mining the drum shaft carries two drums or reels, each running loose on the shaft, but attachable to the shaft through a clutch. Each drum also has its own brake so that the operation of such a hoist requires the use of several levers. If the engine has to stand close to the shaft the rope is a so-called "flat" rope and is wound up on a narrow drum between lateral guides like a strap.

For greater depths the rope drums or reels were mounted directly upon the engine shaft and the steam cylinders were necessarily greatly increased. Among the illustrations is a good example of such a "first motion" hoist—a pair built by the Union Iron Works of San Francisco for the Anaconda Mining Company in 1898 as assembled before shipment. Each hoist consists of two high-pressure cylinders 30 by 72 in. with six auxiliary handling



TAMARACK HOIST—MICHIGAN
(4 cylinders 34 × 60 in.; 6000 ft of $1^1/_2$-in. rope. Courtesy Nordberg Manufacturing Co.)

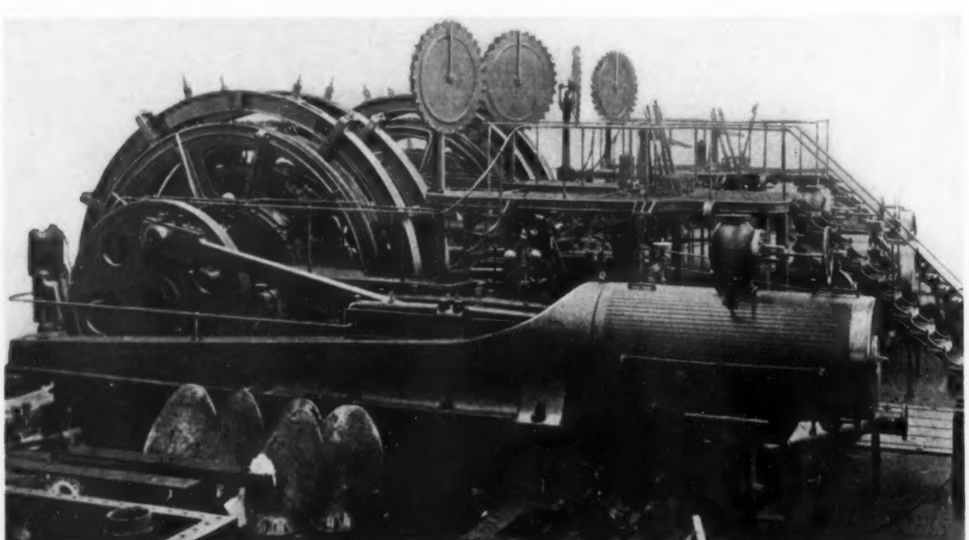
engines for controlling the reverse motion, brakes, clutches, and disk brakes. The reversing engine and the brake engines are fitted with "differential gears" and hydraulic control cylinders as often seen in marine reversing engines. With this arrangement the pistons of the handling engines move proportionally to the movement of the controlling lever; that is, half throw of the lever gives half travel of the piston, and so on. The pistons are locked in place hydraulically at every position. The operator's platform and the dial indicators showing the position of the cage are clearly seen. The ropes are of the flat type, 3000 ft long, and the average hoisting speed was about 3000 ft per min. These were exceptionally fine engines and beautifully finished.



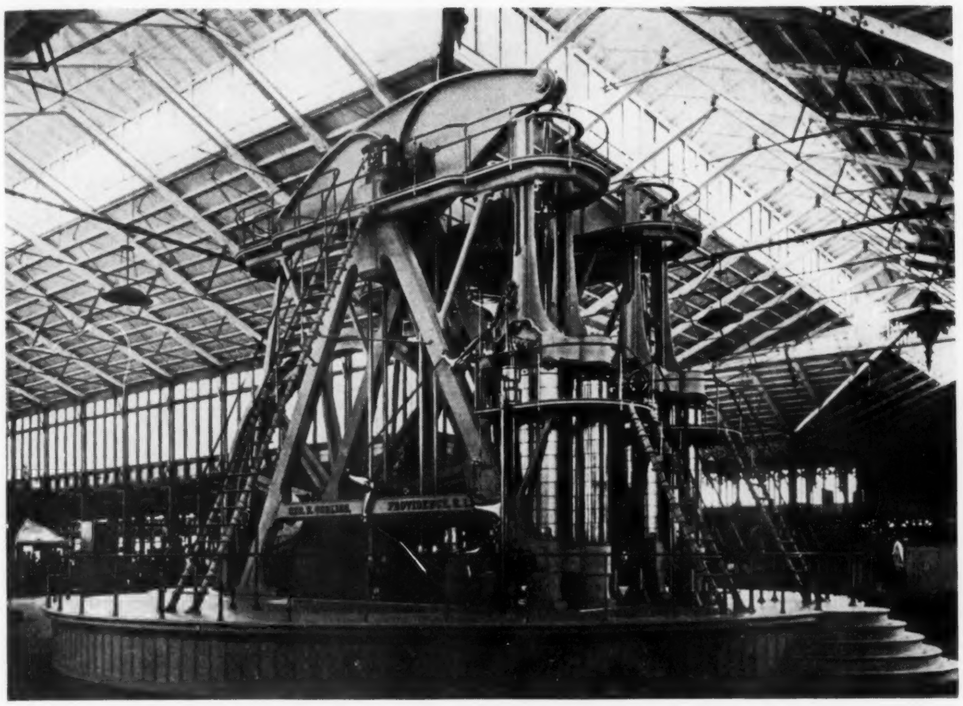
DOUBLE 26 IN. AND 46 × 72 IN. HOISTING ENGINE
(Anaconda Mining Co., Butte, Montana.)

An engraving of one of two great hoists, also built by the Union Iron Works for the Anaconda Mining Company, is included in the illustrations. Each hoist has two compound engines 26 and 46 in. by 72-in. stroke. The high and low of each engine is coupled to the ends of a beam or rocker. The oscillating motion of the rocker gives one end of the connecting rod a motion equivalent to the ordinary crosshead. The other end of the rod rotates the reel shaft. The ropes are flat, $^1/_2$ by 8 in., 3000 ft long, and the hoisting speed is 2500 ft per min. This great engine was modeled after some very large engines designed by E. D. Leavett for the deep copper mines in Michigan. These great Michigan machines, however, were not always exclusively hoisting engines, but performed other functions, such as pumping, or they served a number of shafts as a central power station.

One of the illustrations shows a remarkable hoisting engine designed by the late Bruno Nordberg for the Tamarack shaft of the Calumet and Hecla Company of Michigan. A pair of simple Corliss engines is mounted on an A-shaped frame at each end of the main shaft with cranks 90 deg apart. The four cylinders so mounted give a combined torque curve that approximates uniformity. There is only one rope drum, 25 ft in diameter at the center sloping to 18 ft in diameter at each conical end. The contour of the drum is such that the unloaded descending cage approximately balances the ascending cage, thus making a well-balanced system easy to control. All control, of course, is by auxiliary steam engines. I consider this hoisting engine one of the best pieces of design of its kind that has come within my knowledge. It may be noted in passing that some very large and well-designed hoist-



DOUBLE 30 × 72 IN. HOISTING ENGINE
(Anaconda Mining Co., Butte, Mont.)



THE GREAT CORLISS ENGINE AT THE CENTENNIAL EXPOSITION AT PHILADELPHIA, 1876

ing engines are to be found in the gold fields of South Africa, some of them of English design and manufacture.

"STATIONARY ENGINES"

In applying the steam engine to the many needs of manufacturing the beam engine of Watt was, for the most part, discarded in favor of the more direct system of piston, crosshead, connecting rod, and crank. The beam was used from time to time for large engines, particularly for large municipal pumping engines where the motion was comparatively slow. One of the last and most spectacular appearances of the beam was in the great Corliss engine of 1400-hp erected at the Centennial Exposition in Philadelphia in 1776. It was thought to be a gigantic engine at the time. But for most purposes the so-called "vertical" and "horizontal" type of engine became the prevailing type. By 1850, as has been noted, it had passed through the experimental stage and most all of its elements and variations had been developed. The Corliss gear, the slide valve, the poppet valve, and the Stephenson reversing link were well known by that time and widely used. The great development of the engine came, therefore, during the last 50 years of the last century.

The advent of the electric generator gave a new impetus to designers. At first the generators were belt driven but for obvious reasons this was not a satisfactory solution, and presently there appeared the "high-speed" engine, either vertical or horizontal, with the shaft governor, and with the generator mounted directly on the engine shaft. These engines were necessarily limited in size. When larger generators were required, the Corliss engine and other engines with detachable valve gears being limited to rotative speeds of not much more than 100 rpm, the dimensions of both engines and generators rose to heroic proportions. An 8000-hp horizontal-vertical Allis-Chalmers engine of this period was designed to drive a generator more than 30 ft in external dimensions.

The machine tools developed for manufacturing these engines and generators are probably the largest that have ever been made. This was the high-water mark for the Watt engine. Near the end of the century the steam turbine began to displace it for large power units and the internal-combustion engine began to invade the field of small power units. The future of the Watt engine is, therefore, somewhat uncertain. There are still many places where it provides an ideal power unit and in its improved form of the high-speed Corliss and the uniflow it is hoped that it may have a long lease of life and usefulness. The illustration at the head of this paper shows a 14,000-hp uniflow engine built in 1926 by the Nordberg Manufacturing Co. to operate a rolling mill. This is evidence of the fact that there still exists a place for the reciprocating engine.

THE LOCOMOTIVE

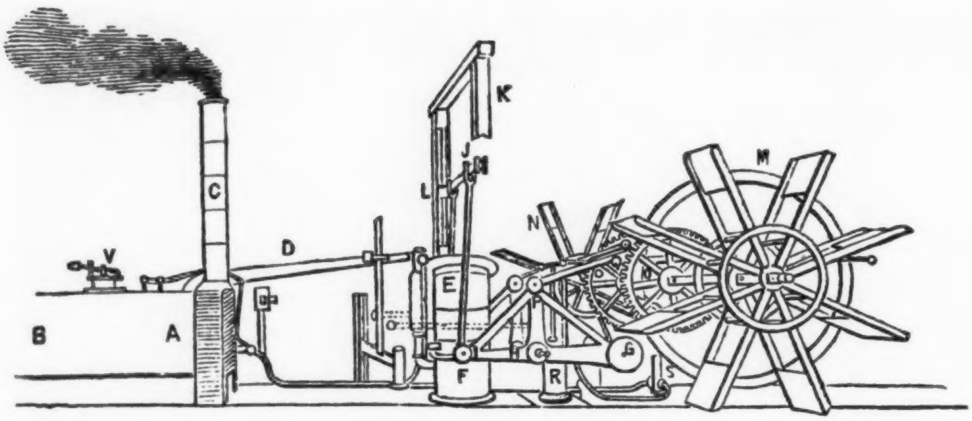
The locomotive, like all other forms of the steam engine, went through a considerable amount of experimentation. Horizontal boilers with vertical or inclined steam cylinders; vertical boilers with horizontal cylinders, and curious combinations of gears and rods appear among these early experiments. From these has evolved one general type that has not

MODERN STEAM LOCOMOTIVE

(Built in 1935 for the Chesapeake and Ohio Ry. Co., by the Lima Locomotive Works. The tractive power is 66,960 lb with the main cylinders and 81,034 lb with the booster. The average weight of the total engine is 477,000 lb and of the loaded tender 381,700 lb. The wheelbase of the engine and tender is 98 ft $5\frac{1}{4}$ in. Steam at a pressure of 250 lb per sq in. is generated from coal burned on a grate with an area of 100 sq ft.)

changed in principle in recent years. It is a far cry, of course, from the *Rocket*, weighing perhaps two or three tons, to a great modern locomotive weighing 200 or 300 tons, but the two machines are identical in principle. One wonders whether a new and more efficient machine might not result, if the designers of locomotives could forget all about what has been done in the past.

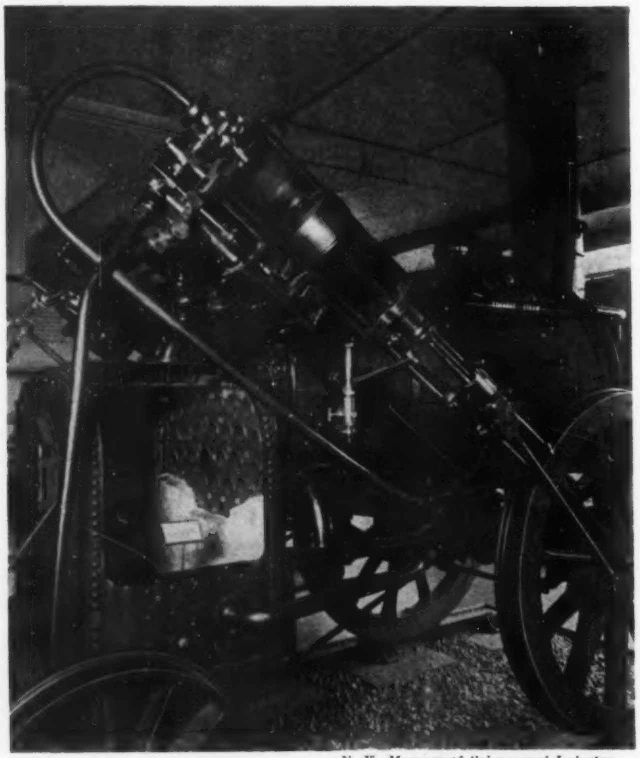
At the present the locomotive is pressed with competition from the autobus, the Diesel locomotive, and the electric locomotive. Undoubtedly, all of these will find a place in our transportation system, but the steam locomotive will probably hold its place in the field for a long time. It is to be hoped that it will if for no other reason than its majestic appearance and as a thriller of adventurous boys.



THE ENGINES OF THE "CLERMONT"
(From Thurston's "History of the Steam Engine.")

THE BOILER

No account of the steam engine can be separated from that of the steam boiler. Space forbids anything beyond the briefest comparisons. Watt's engines operated on pressures only a few pounds above the atmosphere. Today, a steam pressure of 500 lb per sq in. is common and 1200 pounds is not considered extraordinary. Among the milestones of this progress may be mentioned the internally fired Scotch boiler, so long the mainstay of marine power, and the water-tube boiler which made possible the high pressures noted. The accompanying illustrations give some idea of the giant size of some of these modern steam generators and makes one wonder what the limit may be.



N. Y. Museum of Science and Industry

MODEL OF STEPHENSON'S "ROCKET"

THE MARINE ENGINE

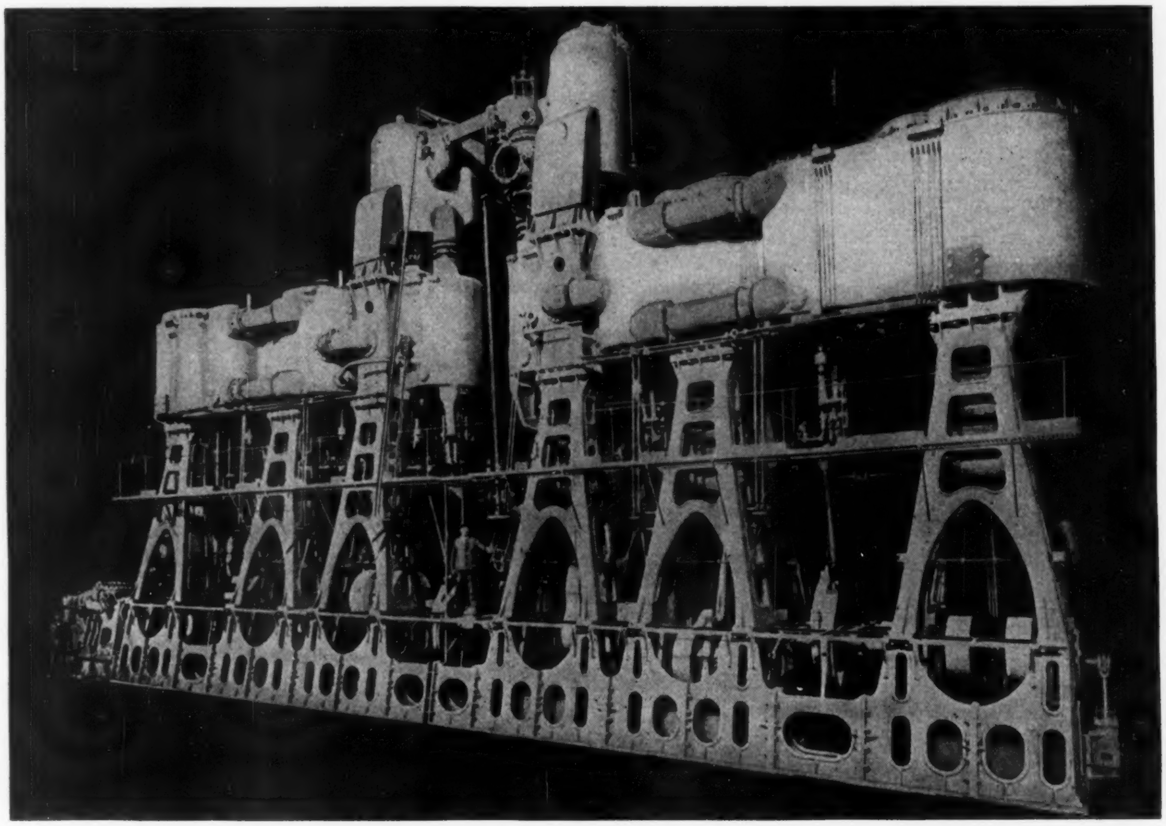
The problem of applying the steam engine to marine propulsion attracted engineers from the very first and much argument still persists as to who among these early inventors is justly entitled to priority of application. The preponderance of opinion in this country ascribes this distinction to Robert Fulton, whose vessel, the *Clermont*, was probably the first steamboat to make a voyage of any considerable length and to engage successfully in commercial work. The accompanying illustrations show that the engine, built by Boulton and Watt, was of the "beam" type.

From the experimental period the marine engine has emerged in several well-defined types, each suited to the work to which it has been applied. The beam as used by Watt has been applied with great success to paddle-wheel steamers on inland waters. The long cylinder permits good expansion, and such engines are smooth-running and durable. The steamers *City of Erie* and *City of Cleveland*, running between Buffalo and Cleveland, are driven by compound beam engines which must give high economy. Perhaps no other type of engine gives one the impression of such great power. The upward thrust of the piston rod, the rise and fall of the crosshead, the reach of the long connecting rod, and the great crankpin swinging through its orbit convey an idea of giant strength that fascinates the imagination.

The illustrations show an inverted beam engine used in various forms when it was necessary or desirable to get the machinery below decks as in gun boats. This type of engine had great vogue as long as paddle wheels were in use in ocean service. There were, of course, other types in use. The *Savannah*, first ship to make the transatlantic trip, was driven by an inclined engine 40 in. in diameter with a 72-in. stroke. The *Savannah* was a full-rigged ship and part of the passage was made under sail.

The advent of the propeller, like the dynamo, at once called for higher rotative speeds. This problem was solved by the introduction, about 1860, of the compound engine, so-called, and the forerunner of the triple-expansion and quadruple-expansion engines of later days. The introduction of the compound engine in marine work was in large measure the work of John Elder, who died in 1869, a brilliant engineer far in advance of his time.

The multiple-cylinder marine engine has been applied as a

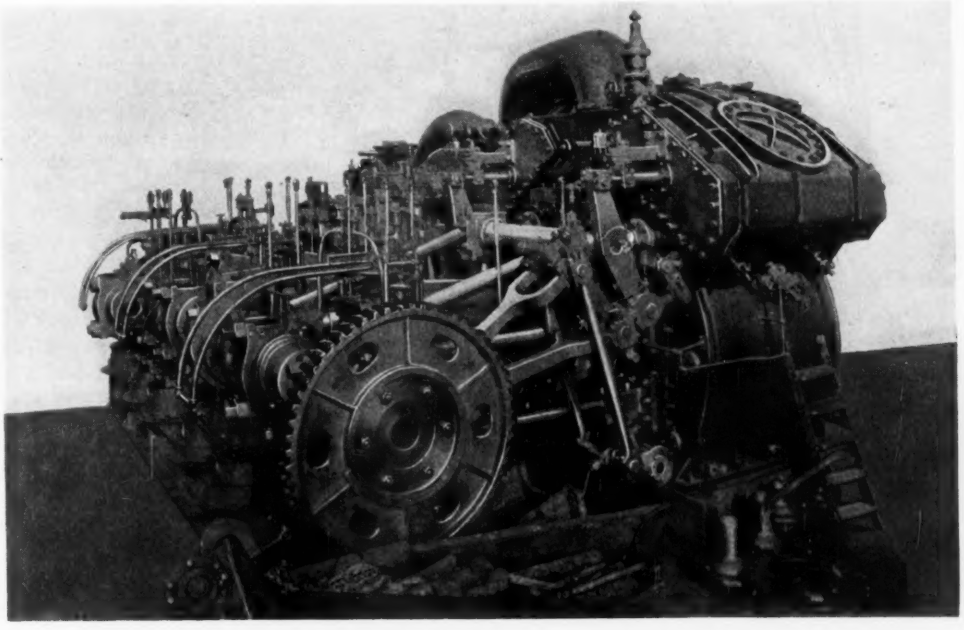


TWO OF THE FOUR 20,000-HP QUADRUPLE-EXPANSION ENGINES OF THE "KAISER WILHELM II"

vertical engine, as a horizontal engine, and as an inclined engine. It is rarely seen today in its horizontal form. The horizontal inclined engine is still used in large inland-water ships. The *Seeandbee*, largest ship in inland waters, plying the Great Lakes, is propelled by side wheels driven by an inclined engine with a high-pressure cylinder 66 by 108 in. and two low-pressure cylinders 96 by 108 in. developing 12,000 hp. Mention should also be made of the long-stroke simple engines developed on our western rivers to drive side wheels or stern wheels for shallow waters. These direct-connected engines are peculiarly American in origin and the valve gears are also peculiar to this service. Space does not permit further description of them.

The highest development of the marine engine is to be found

HORIZONTAL INCLINED MARINE ENGINE AS INSTALLED IN EARLY U. S. NAVY CRUISERS

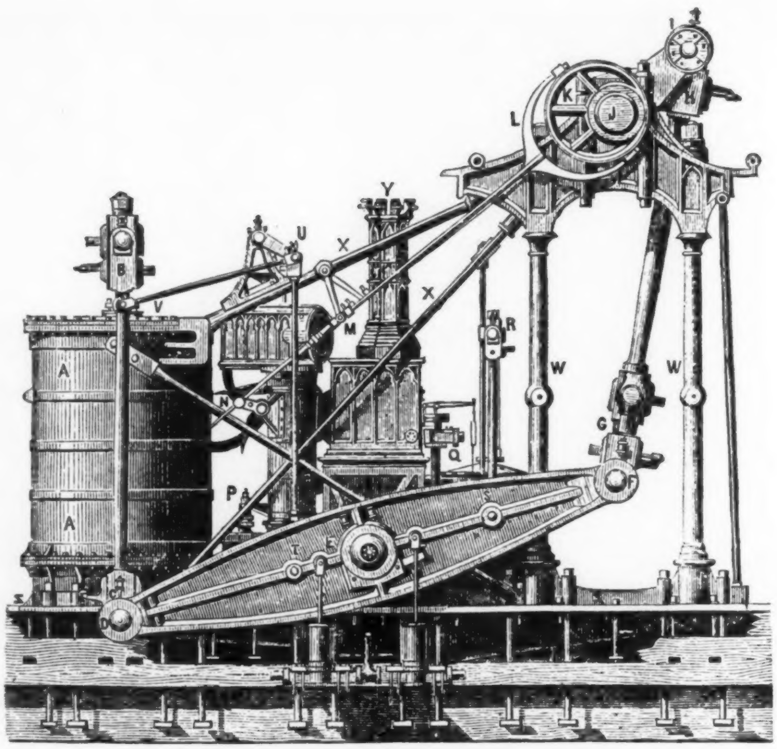


in the multiple-cylinder vertical engines using triple or quadruple expansion. Some of these engines attained great size as shown by the illustration of two of the engines of the *Kaiser Wilhelm II* which developed 20,000 hp, and as can be seen it was a ponderous affair. The vibration inherent with the vertical reciprocation of the great pistons, piston rods, and connecting rods was often a serious problem in design and is one of the principal advantages of the turbine for marine work.

Nevertheless, a four-cylinder, triple-expansion, vertical marine engine, that is, one with two low-pressure cylinders, is the type of steam engine above all others to which an engineer will give his heart away. This form permits of excellent running balance and when equipped with Stephenson links and tail rods is a joy to the eye and music to the ear of a man who loves engines. It is Jamie Watt's engine at its very best.

WATT'S INFLUENCE STILL FELT

Last summer I journeyed from Montreal to Quebec on a steamer driven by two such engines. I naturally gravitate to the engine room of a ship and as I was prowling around on the upper grating the French engineer waved me down to the operating platform. His English was very imperfect and my French is zero but I did not have to understand his words for I recognized at once that here was a French "McAndrew" trying to tell me what the Scotch McAndrew told Kipling many years ago when he prayed for another Burns—

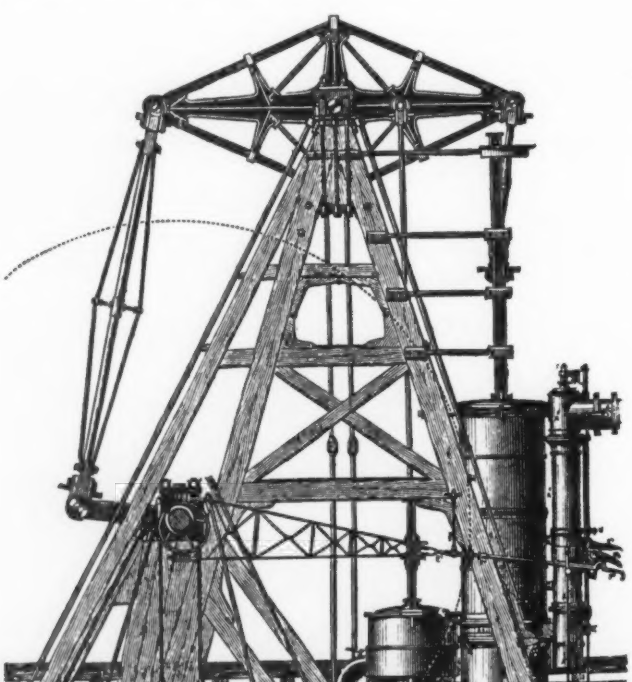


THE SIDE-LEVER MARINE ENGINE OF 1849
(From Thurston's "History of the Steam Engine.")

To match wi' Scotia's noblest speech yon orchestra sublime
Whaurto—uplifted like the Just—the tail-rods mark the time.
The crank-throws give the double-bass, the feed-pump sobs an' heaves,
An' now the main eccentrics start their quarrel on the sheaves:
Her time, her own appointed time, the rocking link-head bides,
Till—hear that note?—the rod's return whings glimmerin' through the guides.
They're all awa! True beat, full power, the clangin' chorus goes
Clear to the tunnel where they sit, my purrin' dynamoes.
Interdependence absolute, foreseen, ordained, decreed,
To work, Ye'll note, at any tilt an' every rate o' speed.
Fra skylight-lift to furnace-bars, backed, bolted, braced an' stayed,
An' singin' like the Mornin' Stars for joy that they are made.

The nineteenth century was the century of Watt, Boulton, Stephenson, Elder, and their many associates and co-workers.

The twentieth century promises to belong to Parsons, Diesel, and the host of able men who have developed the turbine, the internal-combustion engine, and electrical transmission. Yet it does not seem possible that the engine of Watt will pass from view. There still are and probably always will be many places where a moderate supply of power is required and where this ideal prime mover fills the need and I for one fervently hope this will be the case. But whatever the future holds the steam engine of the nineteenth century will be recorded in history as the greatest invention and development of all time in its effects upon the economic life of the human race and Watt will be remembered not only as an inventor but as a benefactor of all mankind.



AN EARLY BEAM ENGINE FOR MARINE WORK WITH WOODEN FRAME
(From Thurston's "History of the Steam Engine.")

WATT—
Symbol of the Industrial Age

By WILLIAM L. BATT

PRESIDENT, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

THE MATERIAL conditions under which we live today are so commonplace to us that we are likely to forget that life has not always been so well ordered. In the abundance of our present civilization it is well for us to recall how comparatively recently this abundance was made possible, and how our forefathers, not so far removed, lived under circumstances of a vastly different character. It was a rather rugged existence for most of them. All a man had was what he could procure with his own two hands unless he belonged to that limited class of society that could afford to hold slaves or employ servants. Means of transportation were limited to foot, to horse, and to wind-blown ships, and life was lived in a narrow orbit. Of amusements there were few, and the day was largely occupied with the work of maintaining a bare existence. These conditions had existed for thousands of years from the beginning of recorded time. They were the conditions under which James Watt was born and lived.

What an extraordinary change has taken place in the short space of time since the birth of Watt. Today we live in comfort and ease; we are surrounded by possessions of infinite variety; and so accustomed have we become to them that what would have been an almost unattainable luxury for the few of a hundred and fifty years ago is a necessity for most of us today.

One of the extraordinary features of the modern industrial age is the fact that, to an amazing degree, it is the direct, traceable result of one man's life and work. This conclusion will seem fantastic to many, and so it would have seemed to me before I was obliged to study more seriously in preparation for this address the life and work of James Watt. Had I been asked to name that single man whose influence on the whole world was most outstanding, I suppose my mind would have searched out some such familiar character as Columbus, George Washington, Robert Fulton, Napoleon, Stephenson, or Abraham Lincoln, or, perhaps, Thomas Edison. Certainly it would never have occurred to me to select a man whose major accomplishment was the perfection of the steam engine. But now I am willing to ask whether we cannot agree, after reviewing the life of James Watt, that the influence of his work has been of greater significance to the world than that of any other single man in recorded history. This thesis I shall attempt to prove.

We shall all doubtless agree that the industrial age which has produced so many miracles has been made possible largely through the availability of power in accessible locations and at reasonable cost. Only through cheap power has man been able so enormously to multiply his own efforts, to produce more things in less time and at less cost, to move himself rapidly from place to place, and, withal, to have time left for rest and play. This economic phenomenon has not been without its collateral problems, many of which are still unsolved. In the brief time at my disposal I shall not attempt an appraisal of the values of this new civilization; I shall merely attempt to analyze its history and the part played by the man whose birth we are commemorating here today.

If Watt had done nothing more

Photograph by W. Mansfield White

STATUE OF WATT AT LEHIGH UNIVERSITY

An address delivered at the Bicentenary of Watt, Lehigh University, Bethlehem, Pa., January 20, 1936, under the auspices of the University, The Franklin Institute of Pennsylvania, the North American Branch of The Newcomen Society of England, and THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

than perfect the steam engine, there might still have been a great gap between his work and the dawn of the industrial era. But during his lifetime, and largely as a direct result of his inspiration, all of the essential elements of industry as we know them today were conceived and put into practice.

For example, it is probable that Watt did more to advance the development of the modern machine tool than is commonly acknowledged. Certain it is that up to his time there was no machine capable of boring a cylinder even reasonably round. The direct credit for the invention of the modern boring mill goes to John Wilkinson, but I think it likely that Watt had a large part in its development. Surely in Watt's lifetime and to a greater or lesser extent as a result of the needs of his engine manufacture, the modern machine-tool industry had its birth. One who visited the Machine Tool Exposition at Cleveland last year and saw that impressive aggregation of machinery capable of producing parts from an ounce to many tons in weight and to interchangeable tolerances of a fraction of a ten-thousandth part of an inch, must have thrilled to man's accomplishments. And all this was developed in the short space of one hundred and fifty years.

I suppose it will be obvious that standardized manufacture is a foundation stone in the economic structure of our day; and if we could agree that Watt was one of the first, if not the first, who saw this as a desirable process, it would aid in establishing my thesis. Certainly, it seems clear beyond argument that Watt's proposal to build steam engines in quantity from more or less interchangeable parts and to a uniform design was revolutionary. Before his time, all such construction was fabricated and assembled where the machines were to be used, and rarely ever were two parts alike. Watt seems to have had a very definite appreciation of exact measurement. His trade of instrument maker logically induced the habit of precise work, and I surmise that it was this quality which made him dissatisfied with existing machine tools and their output. It was natural for him to conclude that good machine tools would have to be designed if good work were to result; and such work could only be carried out at one spot with adequate gages and tools and measuring equipment. So began the modern factory plan. How much of this ambitious program belonged to Watt and how much to his partner, Matthew Boulton, cannot be said too exactly, but it is not too much to credit Watt with a substantial part in these first beginnings of standardized manufacture.

Watt's name is not directly associated with the first successful locomotive, but there seems to be no doubt that he had given the matter much thought and was responsible in considerable part for the road engine built by Richard Trevithick in 1804. There were no principles in that machine or in those soon to follow that Watt had not fully developed, and it is probable that it was only the press of his other work that kept him from constructing a workable locomotive.

I have seen no evidence that Watt had any definite contact with the building of the steamship, but Robert Fulton's *Clermont* was equipped with one of his engines. Thus the steamboat may fairly be considered, in some measure at least, as his contribution.

And so I think you will agree that it is not fantastic to contend that from the one man, James Watt, have come more or less directly cheap power, interchangeable manufacture, the modern machine tool, and long-distance transportation—the very foundation stones of the industrial age.

Now behind such extraordinary contributions to the arts of peace there must have stood an extraordinary man, and James Watt was all of that. It seems clear to me that he had certain well-defined characteristics which were responsible for his success, and that we shall find something in a study of these characteristics that may be of value to all of us. To the young man in college or at the threshold of business life, Watt's handicaps as a youth and the way he surmounted them may be an inspiration. And in the older man Watt's unusual relationships with his associates may awaken a new interest in a closer cooperation with one's own associates; because it is evident that Watt's friendships were preeminent in determining his success. I shall not tire you with a repetition of the biographical facts of Watt's life—you will have heard those many times before and perhaps at length today—but I shall try to visualize the man himself as if he were, perhaps, here with us, working within the walls of this great institution, as he did at the University of Glasgow.

There was nothing remarkable in his appearance; a rather shy person, doubtless we should call him self-conscious; his health not too good and possessing none of those swashbuckling traits that made men stand out in a day of physical accomplishment. Certainly a rather moody person, given to introspection and melancholy. These are the negative traits, perhaps. The positive ones were a heritage of intelligent parents, a painstaking attention to detail, a thorough mind not satisfied with a job half done, and a real genius for making and holding friends. What the friends of Watt did for him is of incalculable significance; but friendship is a force and cannot exist without an equal and opposite reaction. We know that Watt gave generously of himself to his friends; it is clear also that without Dr. Dick and John Anderson and Dr. Black and Matthew Boulton, not to mention many others whom history records, Watt would have missed the wise advice, the inspiration, the scientific guidance, and the business assistance so vital to success and all of which he absorbed and utilized to such an unusual degree. Without the encouragement of these friends, and particularly that of Boulton, Watt would probably have died a disappointed and unsuccessful inventor, for Watt was not trained in business methods, and his type of mind was not fitted to solve many of the problems that were to arise. The intricacies of an astronomical instrument were as child's play to him, but the ways of finance, credit, and the usual demands on the business mind were alien ways to him. To the trusted friend Matthew Boulton, a man of unusual business ability, industrial experience, and financial resources, Watt turned for advice and the partnership between these two lasted till death. It was an unusual business partnership, so charged was it with friendship, loyalty, and mutual confidence; and I cannot emphasize its importance too strongly.

The written and unwritten history of the past is filled with the records of men who almost succeeded in doing some remarkable thing. There was John Fitch, for example, who built and operated a steamboat on the Delaware River years before the *Clermont* was built; but we do not associate Fitch's name with the first successful steamboat. Fitch died a disappointed man and Robert Fulton's name fills the pages of history as the father of the steamboat. Moreover, Richard Trevithick probably built the first complete steam locomotive to run on rails; but Stephenson's "Rocket" is the one we all remember.

The pages of history are filled with similar instances where, with apparently the same resources, one man failed and another succeeded. While there can be no single reason for these successes and failures, man's relation to his fellow man becomes the more significant in determining his progress as the structure of society is increasingly complicated. That man who can supplement his own weaknesses by the strength of others has a great advantage. Here in this center of the production of iron and steel, it may be of special interest to note that Carnegie was never actually an outstanding steel man, although he made a fortune in the industry. His success came from his ability to

FROM CERTIFICATE OF MEMBERSHIP IN THE INSURANCE SOCIETY OF THE SOHO MANUFACTORY OF BOULTON AND WATT

(Discovered among the papers left by Watt in the garret workshop at Heathfield by George Tangye, Esq., and presented by him to Prof. John E. Sweet, who, in turn, presented it to The American Society of Mechanical Engineers. The letter from Watt to Boulton, a facsimile of the end of which is reproduced on page 94, was presented to The American Society of Mechanical Engineers by Mr. Tangye at the joint summer meeting, Birmingham, England, July, 1910.)

surround himself with the finest brains that the steel industry could produce and to possess their loyalty and cooperation. This was the one characteristic of James Watt which, in my observation, contributed most largely to his success.

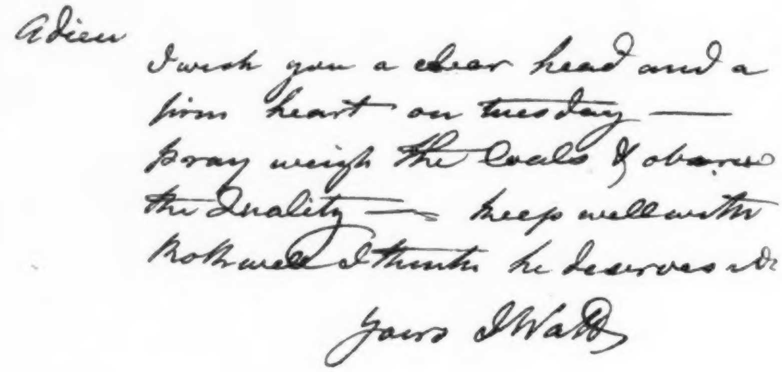
To an increasing extent, this industrial age is demanding cooperative effort and penalizing individualism. Its very existence has depended upon a more or less effective interrelation between production, distribution, and consumption, and the extent to which the individual has forwarded this integrated movement has, to a growing degree, measured his reward. For society is becoming increasingly conscious of its inefficiency in the operation of this intricate mechanism that it has created for the benefit of its own comfort and well being. The spectacle of men anxious to work but unable to find employment; of factory wheels ready to turn but with no work for them to do; of men starving with fields overflowing with food—these are pitifully poor results from an age that has promised so much. Men will not long tolerate such conditions. The history of our own day is increasingly marked with the struggles of great bodies of peoples to work out a salvation for themselves, however violent the forces to effect that end may be. This is not a situation newly made, indeed, one may find in the records of the English Parliament of a hundred years ago protests over the state of things that might appropriately be said of our own times.

In its struggles to find relief our social structure has sought increased mechanization, and has been willing to pay a higher and higher premium for labor-saving devices, the tendency of which, however, is to submerge the individual and interrelate him with the group. Before Watt's day that circle of interdependence was small, perhaps limited to the confines of a village, but in any event, small enough to have characteristics of flexibility. In the intervening years how this circle has grown! From the village to the state, from the state to the nation, and from the nation to the entire civilized world. And in that growth, brought about almost wholly by improved transportation and communication, the individual has steadily tended to lose his individualism and of very necessity to merge his efforts with those of his fellows. Whether the results have been worth the price or not is another question, but there is no doubt that a new group of social problems has developed. And so there inevitably arise those attempts at correction by law, by fiat decree, and by force that are foredoomed to failure. For men cannot be made good, or wise, or kind by law or force. Those characteristics, so much more necessary today than ever before, spring from deeper sources; and while friendship, tolerance, cooperative understanding are not all sufficient in themselves they will go far toward the solution of the manifold human problem of this industrial age. A better understanding between employer and employee; a greater tolerance between people of differing languages and colors; a more willing friendship of man for man wherever their paths cross—these elements are vital to the continued existence of our social structure.

And now for final emphasis, I cannot fail to remark that these qualities, which seem to me to have been so conspicuous in Watt's success, are noticeably lacking in a part of the economic structure with which we here tonight are vitally concerned—the lack of unity in our own profession. Engineers have a certain quality of mind that tends to make them intolerant of any deviation from their conception of a right course of action and

are perhaps unyielding in that give and take which is an inevitable part of cooperation. We have manifested this trait of independence in our professional organizations to the point that we are today overloaded with societies purporting to represent the engineer. We have not sought unity and we have not achieved strength.

The spectacle of scores of national societies and literally hundreds of local bodies with few coordinating elements and distressingly little coordinative force, would not be surprising if it were that of any other profession than ours. But our education and training have been of another kind. It has been basic to us to emphasize absence of waste motion and simplicity—all of those elements that go to make up efficiency. Indeed, most of us base our livelihoods on the practice of these principles. Have we applied them to the organization of our own profession? I fear we have not. Instead of a great united body of scientific and technical men, so organized as to appraise its social and economic responsibilities and to present a united and determined front, we seem only interested in our own little corners and the narrower confines of our own local interests. If an effective degree of professional unity is to be achieved, some sacrifice will be involved; but what a vision there is of the possibilities that may flow from such a union.


Adieu
I wish you a clear head and a
firm heart on tuesday —
pray weigh the Coals & observe
the Quality — keep well with
Rothwell I think he deserves it
Yours JWatt

Is it too much to conclude that the very life of the industrial age and of our present organized society may hang in the balance? Unity of the engineering profession can be achieved if the leaders of the scores of national societies and hundreds of local societies, supported by the tens of thousands who comprise their membership, will set as their single guide these characteristics of friendship, tolerance, and cooperative understanding—these selfsame characteristics that stood out in strong relief in James Watt's life, that bound him to that extraordinary circle of friends of which we have heard so much today and without which his inventive mind and mechanical genius might well have gone for naught. Without these qualities of mind and heart in this industrial age of Watt's creation—in this profession which has had so significant a part in its growth—it and we may go as other futile civilizations of the past and their peoples have gone.

HEATHFIELD, WATT'S HOUSE AT HANDSWORTH HEATH, BIRMINGHAM, WHERE HE SPENT THE LAST YEARS OF HIS LIFE

(From Smiles's "Lives of Engineers.")

PROGRESS *in* POWER—*A Review*

By CHARLES E. LUCKE

COLUMBIA UNIVERSITY

A REVIEW of progress in power is consciously or unconsciously guided by some conception of what constitutes progress, and by what standards it is to be judged in dealing with the fact data of the 1935 reports of the several professional divisions of The American Society of Mechanical Engineers. These reports are devoted to new engineering developments, and improvements in generating equipment or in operating procedure are recorded and discussed. A summary of these developments is usually accepted as a review of progress in power on the assumption that power progress is the same thing as engineering development. However, there seems to be some advantage in the unconventional hypothesis that however necessary engineering development may be to progress in power, these things are not identical, and the former does not always mature into the latter.

Whatever may be the meaning of progress, it is clear that a review should be something more than a statistical statement. It should have some elements of judicial opinion. An editorial differs from a reporter's story in the daily papers.

OBJECTIVE OF PROGRESS IN POWER IS REDUCTION IN POWER COST OR IMPROVEMENT IN SUITABILITY OF PLANT

The true objective of progress in power is reduction of power cost, or improvement of suitability of generating plant for a special case or class of drive in any of the divisions of transportation or stationary service. Whatever has reduced power cost is thus proved to be an item or a means of power progress, and the same is true of anything that improves the suitability of equipment for a given service without increase of power cost beyond what can be borne. There can be no absolute measure of progress. Comparison of new with old on a competitive basis as to power cost and service suitability must determine when progress has been made. Those new engineering ideas or inventions, newly developed processes or equipment that are the result of a power-progress motive, may or may not finally be entitled to such a claim. The conclusion must be deferred until after acceptance and use in competition with alternates. Progress certainly is not measured by novelty alone, whether engineering progress or power progress.

While conclusion must thus be deferred, there is value in a weighing of possibilities of engineering improvements as prospective means of making progress in power. This sort of thing is, moreover, quite necessary in the formulation of plans, programs, and policies by engineers and organization executives concerned with any phase of power activity. Usually each one prefers his own opinion, and there is just as much competition between opinions as there is between alternate power-generating systems and equipment.

Interpretation of facts to discover trends may be as important as the facts themselves, and it may indicate directions worthy of effort in the interest of progress, or, negatively, directions in which no effort seems worth while. Identification of trends really amounts to forecasting, dangerous but necessary, and it requires information on both tangible things and intangibles, the interpretation of which may lead to conclusions as to what should or should not be done with no specific evidence in that direction.

THREE MAJOR TYPES OF PERSONS CONCERNED WITH POWER PROGRESS

There are three major types of persons concerned with power progress and each may properly set up different standards of judgment as to advances in its own zone of activity: (1) The power user and engineer of utilization or application of power; (2) the manufacturer of power-generating equipment, and the designing engineer; and (3) the operator of power equipment and the operating engineer, independent of power use and of creation of means of power generation. The power user must be put in first place as the supreme court of judgment of competitive cost of power and of the suitability for his purpose of alternative means of generation, the supplying of which is the business of the other two groups.

The other two groups whose attention is necessarily concentrated on alternative means of generation must deal with sources of energy, efficiency of transformation, apparatus design, and performance limits, but here novelties that are engineering improvements worthy of notice as items of engineering development may not be classed as real contributions to power progress until accepted by the first group, the user, as competitively better for his purposes than what had been available. Admiration for the ingenuity of the designer or inventor, for the profundity of knowledge of the research engineer, or for the resourcefulness of the solver of technological problems is apt to obscure the fact that the result is acceptable and salable to the user only when the new generating equipment produces cheaper power, or is more suitable for his needs.

While the user group is the one that must pass judgment on progress as to competitively acceptable improvements in generating equipment, the exercise of this judgment by one class of user has been too often limited by disinclination to change an old practice, thus minimizing the prospective value of new means perhaps developed and in successful use by another class of user, and so close the door to possible progress arising from the efforts of the other two groups concerned with the improvements of means. Open-mindedness on the part of user groups is a prerequisite which is essential to all power progress.

There is evidence of progress by all three groups, both tangible and intangible, the tangible being concerned with creation of improvements in new equipment, in operation of equipment, and in user acceptances, especially as between different groups of users, such, for example, as stationary in relation to transportation classes of users. Some observations and comments on progress are given in what follows in four classes, the first being general as to systems of generation, and the last three based on the steam, internal-combustion, and hydro systems, respectively. Some are items of power progress, others of engineering development, and each reader may judge for himself the relation of the latter to the former.

Based on the 1935 Progress Reports of the A.S.M.E. Divisions on Fuels and Steam Power, Oil and Gas Power, and Hydraulics; the Edison Electric Institute Prime Movers Committee; and the Association of Edison Electric Illuminating Companies' Power Generation Committee. Presented at the Annual Meeting, New York, N. Y., Dec. 2–6, 1935, of The American Society of Mechanical Engineers.

GENERAL FACTORS IN POWER PROGRESS

Intangible progress is evidenced by rapidly growing acceptance by all three groups of research, properly defined and properly directed, as a necessary activity instead of something to be suppressed as a nonproductive expense. This was mentioned last year[1] with reference to means of generation, but it is being extended to the user problem of selection or adoption of alternate driving equipment. The key to this problem is rationalism of analysis of relations between cause and effect, as distinguished from empiricism or tradition, and rational analysis has never been so actively accelerating in so many directions as now.

In fuel-burning systems the extent to which premium prices for special grades of fuel and the corresponding increase of fuel expense per horsepower-hour may be justified by increased suitability is receiving more attention and new answers are to be expected. Should fuel be processed with cost addition to suit burning equipment, as, for example, in the gasoline engine? Should higher-priced fuels be selected from grades available but not equally suitable, as, for example, coal for a given stoker? Or on the other hand, should burning equipment be designed to be more independent of fuel grades and kinds, both in internal-combustion engines and in steam boilers? Which practice will best promote progress?

The proper degree of operating reliability in relation to life, and to life per unit of capacity per dollar of investment for generating equipment, is an old question that has been differently answered for transportation motive power especially with internal-combustion engines, compared with stationary service in units of various sizes. It needs further study and clarification.

Increase in reliability in fuel-burning systems has been an objective and its attainment in many directions a more notable mark of progress than increased efficiency. It contributes both to increased suitability or serviceability and to reduction of power cost in transportation motive power and stationary power plants using either steam or internal-combustion systems.

In aircraft engines an operating period of 500 hours without overhaul is now commoner than one of 50 hours at the end of the War, and in automobile engines the foolproofness that has become standard and permits of an operating life in unskilled hands of about 1000 hours without overhaul, is a real achievement.

In central-station practice where the most highly skilled operators are the rule, reliability reduces power cost through reduction of expense of outage or its equivalent fixed charges for spares, in addition to other items, and considering what the boiler must do, the following quotation from the recent report of the 1935 Prime Movers Committee of the Edison Electrical Institute is evidence of true progress: "Boiler availability for high-pressure units compares favorably with, or exceeds, the turbine availability," and the availability factor is 90 per cent more or less.

STEAM DEVELOPMENTS

Coal is the most abundant fuel and always will be, so its utilization to the maximum degree is a matter of importance in the interest of reduction of coal expense per horsepower-hour with growth of power production, and coal-burning furnaces with increased independence of rank or grade of coal would contribute to power progress. Equally so is the furnace that can burn alternate fuels, oil, gas, or coal, with the least change in structure, reliability, and efficiency of absorption of heat, when and where heat in one of these forms may be cheapest. The universal fuel furnace is truly a power-progress objective.

[1] See "Progress in Power," by C. F. Hirshfeld, MECHANICAL ENGINEERING, February, 1935, pp. 99–102.

Greater reduction of fuel expense per horsepower-hour is possible in this direction than by increased efficiency of plant. This is a phase of reduction of premium prices for fuel, but also one of improved operating reliability through increased independence of grades or kinds. At the present time, development in pulverized-coal furnaces, which are suitable for a variety of grades of coal, and for gas or oil, is the most promising line of attack.

The successful use of high pressures and temperatures in stationary practice, the figures for which are the same as last year, 1400 lb at 850 F with reheat, or 600–800 lb at 800–900 F without reheat, except for 1400 lb at 900–950 F, is beginning to affect marine practice, an especially conservative section of the user group. This is an interesting observation in view of the fact that ships have been the laboratory for the development of Diesel engines. Some American steam vessels are now operating with 450 lb and 750 F and some foreign ships at 600 lb and 850 F, but current American proposals reported last month by William W. Smith, chief engineer of the Federal Ship Building & Dry Dock Co., Kearny, N. J., to the Society of Naval Architects and Marine Engineers are in line with stationary practice of 1200 lb at 950 F.

The dominance of steam in large capacities with turbines, and the successful competition of Diesel engines in small capacities burning premium-priced fuels, noted last year, are concentrating more attention on the reasons for the situation and the possibilities of changing it.

High efficiency, necessary for a competitive fuel expense, imposes high steam pressures on the small steam plant for a high cyclic efficiency, but the turbine has been unable to utilize it efficiently in small units. Does this mean that turbines never can succeed here? Does it mean that the reciprocating engine may be revived for this service? If so, the multicylinder, balanced, high-speed gasoline engine is a model of mechanism that could be easily adapted to double-acting steam cylinders. There is no difficulty in producing suitable boilers. Progress in this direction, now definitely problematical, has as a motive the removal of existing fuel limitations as to kind and price from power-generating units of small capacity, equally suitable for stationary service and for transportation motive power, especially for locomotives and small ships.

Lack of improvement in maximum efficiency of steam-power generation in the interest of reduction of fuel expense per horsepower-hour or kilowatthour provides a motive for effort to correct the condition, and success in this direction would be real progress. The near approach to what seems to be the limiting efficiency for steam, without increase of other items of power expense or loss of service suitability, is responsible for an effort to find new chemical compounds of proper physical properties for power cycles of a single fluid, or with several fluids cooperatively. The mercury-steam installations at Kearny and Schenectady as examples of dual vapor cycles in series are noteworthy examples of increased efficiency. Bringing these to the state of satisfactory operativeness has meant the solution of innumerable engineering problems, many with no precedent, and is a noteworthy development that stimulates interest in future reports on the effect on power progress.

Chemical efforts to produce new and satisfactory working vapors are to be encouraged, especially in view of success attained in development of new refrigerants of desired properties. Thermodynamic study of multiple cycles is also worth while, particularly with the objective of finding regenerative cycles of two or more working fluids that may approach most nearly the ideal condition of constant-temperature addition of all input heat, and constant-temperature abstraction of all heat necessary to close the cycle, and correcting the inefficiency

effect on cycles of temperature changes with heat content of the working fluid.

Much progress in steam-power generation is to be expected in another direction, that of raising the efficiency and reducing the fuel expense of those units that have less than the maximum attainable efficiency of the system. Development of ways and means of solving this problem of economic modernization of old equipment, or of its disposal and replacement, has been intensified by the depression, and results of great value are to be expected.

Progress in steam power in central stations is more evidenced by rational analysis of possibilities and programs of execution when additional capacity is needed, than by actual tangible progress, but this result seems to be just around the corner. The planning for most economical ways of additing capacity has for one of its objectives the best means of salvaging or replacing old, obsolete equipment as applied to the individual station and to a system of several stations as a whole. Superposition of new high-pressure units on old low-pressure units is one possibility that looks promising. The distinction between interstate and intrastate system operation, resulting from recent government action, is a new factor in this study of how to make progress in central-station generation when the time for action arrives.

From the reference reports of the A.S.M.E. Fuels and Steam Power Divisions for 1935, some items have been abstracted. These are all engineering developments and their relation to power progress is open to interpretation by any one:

Lack of new installations, no outstanding developments, concentration of effort on improved operation and solution of many detailed problems. Improved equipment availability factors, especially for high pressures in central stations and warranting unit arrangements of high-pressure boilers and turbines. Modernizing programs in both central stations and industrial plants. In boilers: Extension of waterwall practice to underfeed stokers; continued trend toward pulverized coal and toward unit system; more flexibility and wider range of pulverized-coal burners; slag screens in pulverized-coal furnaces; keeping tube bank clean; cinder, dust, and fly-ash control; increased use of stokers in small capacities under 1200 lb per hr and increased use of sprinkler type; treated feedwater in place of condensate; control of superheat, especially after a change of fuel; remodeling of furnaces to increase dependability and increase capacity; determination of circulation limits of high-level water tubes and correction for overheating zones; steam washing to reduce superheater and turbine deposits; continued use of drumless boilers abroad and study of competitive situations here. Pipe-joint welding increasing and stress relieving of metal; special metals. Turbines: Perfection of details; better materials; casing growth; blade corrosion; erosion and inspection; special oils and oil treatment; high-speed proposals for large units. Condensers in general unchanged; tube materials; slime control. Pumps: Improved packing, bearings, and supports.

INTERNAL-COMBUSTION DEVELOPMENTS

Gasoline-engine practice in powering automotive vehicles, while proceeding steadily without revolutionary changes, is, nevertheless, making progress that should have reactions in other directions.

(*a*) The practicability and utility of reliable balanced high-speed reciprocating units of good torque characteristics is a demonstrated fact, and the adoption of similar mechanism for high-pressure steam engines is feasible, if it is found that they are found to be economically justified.

(*b*) The large production volume of identical small units with modern shop tools and methods has proved that power-generating capacity can be produced at a low cost in this way. The new Ford V-8, 90-hp engine at 3800 rpm peak weighs 500 lb and retails at $135, or $1.50 per hp at the peak, and $0.27 per lb. The production of automobiles and trucks for 1935 is expected to be four million, and the horsepower capacity can be estimated by any one. Adoption of this system is now being extended to Diesel engines, primarily for tractors, and it is making cheap units available for isolated-plant stationary service and for other transportation motive power but with limited life.

(*c*) Low cost of power-generating capacity permits a correspondingly low total life without increase of, and perhaps with decrease of, fixed charges per horsepower-hour, reduces the problems of disposal of obsolete equipment, and encourages new development for replacement, especially as elapsed time and operating-life period approach equality by continuous use.

Interurban truck operation of nearly 24 hr per day is an illustration of the latter point. This general practice of producing cheap capacity of short life prompts inquiries as to the proper relation of it to the opposite one typical of large stationary stations, of building equipment for long life, 20 to 40 years, at a higher cost per unit of capacity, even for equal fixed charges, balancing cost of capacity against life.

Gasoline-engine performance has reached its peak in the radial air-cooled aircraft engine, of which the Wright "Cyclone" is an example of the largest size and maximum capacity per cylinder, securing 166.6 brake mep at 1950 rpm with supercharging in nine cylinders, $6^1/_8$ in. by $6^7/_8$ in., or 83.4 hp per cylinder. This is a total of 750 hp, with a gasoline consumption of 0.60 and 0.48 lb per hp-hr with and without supercharger, respectively, and a total weight of 1000 lb, or 1.31 lb per bhp and 0.53 lb per cu in. of displacement.

Substitution of fuel oil for gasoline, the Diesel engine replacing the gasoline engine as transportation motive power is an example of reduction of premium prices for fuels processed to fit an engine, by changing the engine from the carburetor to the injection mode of utilization to fit the cheaper fuel, but it is threatened with loss of advantage by excessively detailed specification of grades of fuel oil. This again invites attention to the desirability of a liquid-fuel engine of such design as will be independent of grade of fuel, or as much so as possible to insure maximum suitability and minimum fuel expense in power generation.

The motive-power cost competition between motor ships and steamers continues, but the situation seems to be clearing up. While European practice still favors motor ships of larger size than American, both agreeing in adopting steam for the highest capacities, the European trend toward larger Diesel engines, 20,000 hp more or less, is not so marked as it was, as marine steam-plant efficiency is being raised. For ships requiring 2000 hp or less, Diesel power is in general cheaper than steam, and the competitive range of sizes now lies, internationally, somewhere between 2000 and 15,000 hp, with a lower maximum here, and with some exceptions at both ends.

The adoption of Diesel motive power on rails, especially for locomotives in competition with steam, continues, and has stimulated development of new designs. The relative competitive merit of the two types as to service, suitability, and power cost will not be known until the end of the period of evolution.

From the reference report of the A.S.M.E. Oil and Gas Power Division, for 1935, some items have been selected, as possible contributions to progress in power to be judged by appropriate standards:

Increased use of high-speed automotive-type Diesels in trucks replacing gasoline, more than 2000 in use and five manufacturers; growing demand for similar units for boats under 50 ft. Three new manufacturers' designs of submarine engine developed—Winton, Fairbanks-Morse, and Hooven, Owens & Rentchler, same for rail cars and locomotives, with others by McIntosh and Seymour and Ingersoll-Rand; the

use of the opposed-piston engine in submarines and rail cars; the Busch-Sulzer V-type locomotive engine; the 3600-hp Winton locomotive engine for the Santa Fe. Trend toward high-speed engines for marine service; high efficiency of Sulzer engines in the M.S. *Dorset* and *Durham*, 0.35 lb oil per hr per shaft horsepower for all purposes; use of exhaust-steam boilers on ships. New Diesel manufacturing plants of Atlas-Imperial, at Matoon, Ill., Hill, at Lansing, Mich., and Worthington, at Buffalo, N. Y. Production for 1935 estimated at twice that for 1934, from $^3/_4$ to $1^1/_2$ million horsepower.

HYDRO-POWER DEVELOPMENTS

Characterized by what is probably a higher cost of potential energy in form available for use in the prime mover than for any fuel-burning system, owing to fixed charges on water-concentrating and protective works, by irregularities in supply, fixed location without reference to markets, and as near to 100 per cent efficiency of utilization as man may expect to reach, it is surprising that the unique difficulties in making progress in hydro power are not better understood, especially with the constant strengthening of competitive generation of power by Diesel or steam units located at the power market or point of use, to which point the hydro power must be electrically transmitted.

In spite of these limitations, with the possibility of local generation by Diesel engines in small capacities, or by steam plants for larger capacities at power costs competitive with, or lower than, transmitted hydroelectric power, hydraulic-power-plant construction proceeds. It is significant that these are mainly government projects. As fuel-power progress proceeds, hydro should recede.

Hydraulic turbines at their best have not been made more efficient than they were. It is hard to see how they could ever be more efficient, since all hydraulic and mechanical losses are but little more than 5 per cent. Moreover, they are no cheaper except as larger size may reduce cost per horsepower, nor more serviceable as to reliability or other operating features except perhaps in some minor matter. Engineering developments applied or applicable to them have made it practicable to build larger ones that could have been produced before, but hardly better ones.

Perhaps as important as turbine improvement is the effect of the use of methods employed in perfecting turbines on the development of pumps utilizing similar hydraulic principles but required to meet a wider range of conditions of head, speed, capacity, and temperature with all sorts of liquids, including dirty ones carrying solids in suspension. This is, of course, not direct power progress, but an engineering development growing out of former hydro-power progress. It is applicable to progress in the power-consuming field, but also applicable to power progress as pumps are used as auxiliaries in steam-power plants.

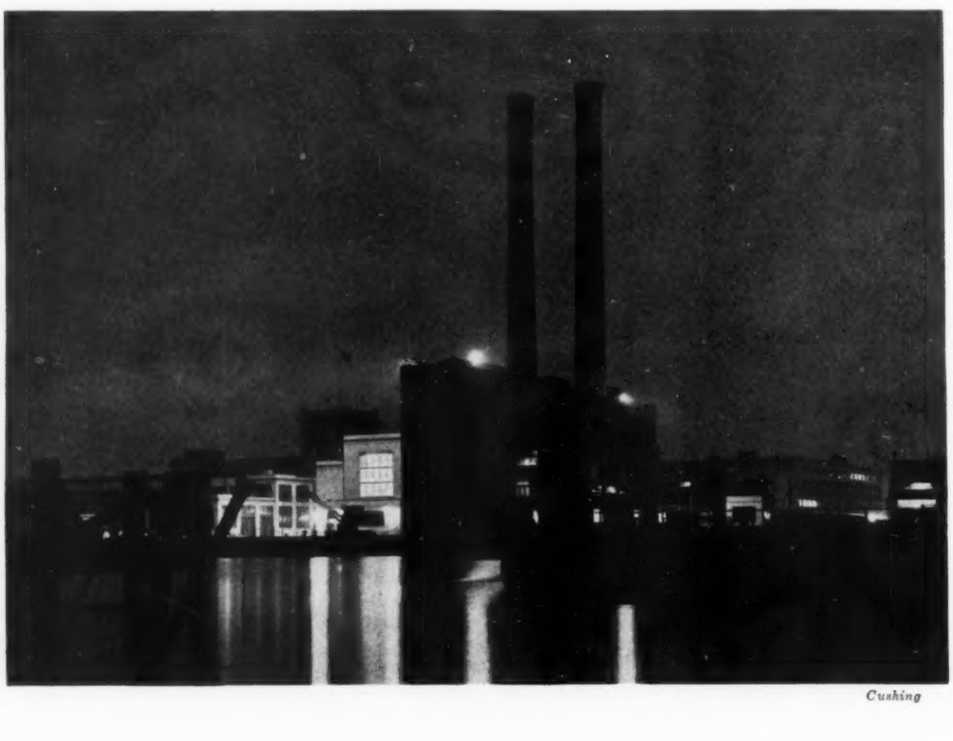
Especially interesting is the report that the efficiency of some centrifugal pumps has been brought above 90 per cent, in line with that of turbines, considered, only a few years ago, to be an impossibility.

The reference report of the A.S.M.E. Hydraulic Division for 1935, notes the following items of development:

Large sizes of Frances turbine, 100,000 hp at 123 ft for River Dnieper, Russia; 115,000-hp at 420–590 ft for Boulder Dam; and propeller turbines of 45,000 hp at Wheeler Dam. Centrifugal pump lifting water part time, for turbines proposed for Passamaquoddy along lines used at Rocky River station, Connecticut. Centrifugal-pump design research at California Institute of Technology, associated with specifications for pumps of supply pipe line across the State of California in five stations with fifteen pumps of 200 cfs each, and 146 to 444-ft head, totaling 600 cfs against 1634-ft head and requiring 137,500 hp drive. Pumps at Grand Coulee of 16,000 cfs capacity against 290-ft head. Rational analyses with experimental data of cavitation limits; and reduction of entrance acceleration at pump entrance, leading to more reliable pumping of liquids at saturation temperature, and liquids with gases, with some application to steam-power plant service.

CONCLUSION

In conclusion, progress in power may be expected in proportion as engineering developments of ways and means are effectively prosecuted. The advance of engineering itself, being what it is, the future of power progress is very bright, and will remain so as long as the efforts of the engineer are properly supported and are not neutralized by influences beyond his control.



Cushing

Formation and Growth of SUGAR CRYSTALS *in* VACUUM PANS

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In a number of bulletins descriptive of the research and development work done by us on calandria vacuum pans, the subject of the formation and growth of sugar crystals has been mentioned many times. During these investigations, certain important corollary conclusions became unavoidable, and it is the purpose of the present discussion to review the data carefully, inasmuch as they compel revisions in our concept of the actualities of sugar crystallization.

PRESENT PROCEDURE

It is appropriate to summarize the generally accepted procedure in the elaboration of a strike of sugar. The first step is the making of the grain and its subsequent preparation. Before going into detail, it is wise to consider certain fundamentals bearing on the subject.

UNIFORMITY OF INITIAL NUCLEI

In the past, the literature has indicated the advisability of obtaining the greatest uniformity in the fine grains which are the starting points for the eventual full-grown crystals. Various methods of effecting this result were given in detail. It is felt, however, that the significance of this feature has been somewhat exaggerated.

Actually, extreme uniformity is relatively unimportant, as will be gathered from the following facts. Consider the characteristics of any solid of regular formation, such as sugar crystals, and observe that:

(1) The linear dimension varies directly with the magnitude of the dimension.

(2) The surface of the solid varies with the square of the dimension.

(3) The weight or volume varies with the cube of the dimension.

One of the principal factors controlling the rate of growth of crystals is the area of their surface exposed to the supersaturated syrup. The exact weight of the initial individual small grains when they are formed is a very difficult matter to determine. They are of microscopic proportions. Perhaps a practical example might shed some light on the subject.

In a large sugar factory it has been found possible to seed completely a 14-ft vacuum pan with about 10 lb of extremely fine sugar. The final strike produced about 72,000 lb of commercial product. No new crystals were formed during the strike, which contains the same number of crystals as were in the original 10 lb of seed. From this it may be seen that for each individual crystal:

(1) The increase in weight and volume was 7200 to 1

(2) The increase in crystal surface was 361 to 1

(3) The increase in linear dimension was 19 to 1.

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When grain is actually formed in the pan it must be even finer than this fine seed. The variations of size of the individual nuclei must be appreciable, since it takes perhaps fifteen or more minutes, according to purity, to bring out the full crop. The point of importance, however, is that considerable variations of weight in the ultimate crystals, after they are full grown, involve relatively smaller variations of linear dimensions. Thus it can be seen that a crystal weighing one-half as much as another will have its linear dimension reduced by only 20 per cent, a variation which to the eye is relatively unimportant and substantially negligible from the standpoint of satisfactory commercial sugar.

SMALL CRYSTALS GROW FASTER

Since the increase of weight and volume is directly proportional to the surface of these crystals, it follows that the smaller crystals will gain weight and volume faster than the large ones. In fact, the rate of weight and volume increment of the individual crystals will be inversely proportional to their size. This extremely important fact becomes an automatic corrector of irregularity. It is our inevitable conclusion from this that excessive size variations are due not to irregularities in the size of the initial grain, but rather to the fact that during the strike new grains are formed at a time when they are neither expected nor wanted. All of this comes from the conditions prevailing in the pan during operation, which are not suitable for uniform crystal development, and hence the defective result.

HOW SUGAR CRYSTALS START

There are several methods of bringing about the formation of the initial grain nuclei, which are given briefly as follows:

(1) The original technique of making grain is to "let it come in." This was accomplished by concentrating a charge of syrup progressively "dead end," until the supersaturation reached a high point, in the neighborhood of 1.35 to 1.40, at which spontaneous formation of crystals took place of its own accord without any external influence or manipulation. That is to say, fine microscopic grains of sugar began to form in the heavy syrup.

(2) Another very popular method of starting crystallization in vacuum pans is the so-called "shock system." The procedure consists of drawing in a certain limited quantity of fine sugar crystals, with the simultaneous admission of air, when the supersaturation has reached a point established at approximately 1.20 plus. The shock produced by the presence of these crystals accompanied by the inflow of air causes a new crop to form much before it would in the aforementioned "waiting method," and as a rule, a more uniform and satisfactory grain.

(3) The third method is by "seeding," or the introduction into the strike of the full number of fine crystals which will eventually grow to the ultimate size required without the formation of new grain. In this case the seed is introduced just after saturation has been reached. Various authorities advise different procedures as to the quantity and fineness of the seed.

How far this can vary will be understood from the fact that it is possible to seed a 14-ft vacuum pan with as little as 10 lb of fine sugar. On the other hand, two or three tons may be used. In this instance, the size of the seed is proportionately much coarser. In other words, there would be the same number of crystals in the 10 lb of seed as there is in the charge of two or three tons, if the same coarseness of ultimate sugar is to be made.

Outside of the inconvenience of handling the large bulk, the advantage is in favor of the large seed. The crystals have much more accreting surface and thus avoid a difficult stage in the operation of controlling the growth at the beginning, which has always been a ticklish matter.

PREPARING THE GRAIN

Having the starting nuclei in the pan, obtained by the waiting method, the shock system, or the seeding system, the next step is the preparation of these crystals for further growth, or, as they say, "hardening the grain." Stripped of all unnecessary verbiage and local terminology, this consists of preventing the formation of new grain while at the same time causing the existing crystals to grow at the maximum possible rate until they are large enough to absorb the sucrose from the surrounding syrup as fast as it is made available by evaporation. This sounds easy, but it is the most critical stage of the entire operation of sugar boiling.

The reason is not difficult to find. It has been mentioned that it is possible to seed a 14-ft vacuum pan with 10 lb of fine sugar. For the sake of simplicity, let us assume that this quantity of sugar nuclei is present in the 14-ft strike at the start, irrespective of the method by which it has been obtained. The rate at which these crystals can be made to grow depends principally upon two factors, namely, the supersaturation of the syrup and the surface of the crystals. It is generally conceded that maximum rate of growth will be obtained when the supersaturation is in the neighborhood of 1.20. This varies somewhat with the purity, but the point is that there is a maximum concentration for fastest crystal growth, and if this is exceeded, not only will the accretion of sucrose on the crystals be impeded, but there is imminent danger of forming undesired new crystals; "false grain." If the concentration is too low, then the rate of crystal growth will decrease also, and stop altogether when saturation is reached.

Since at the start the sum total of the surfaces of the crystals present is only $^1/_{361}$ of what it will be at the end of the strike, it is evident that it is possible to make sucrose available by evaporation much faster than it can be absorbed by the sugar crystals; hence, if evaporation is allowed to go on unrestricted, the supersaturation will rise and false grain will come in. On the other hand, active massecuite movement must be maintained for uniform crystal development, and this movement cannot be achieved without evaporation, and thus a dilemma.

There are several methods of solving the problem. One is to feed water into the pan, so-called "movement water," which is admitted at a rate sufficient to prevent excessive supersaturation, while the rate of evaporation is maintained fast enough to give the proper circulation and movement. As the crystals grow and acquire more and more surface for sucrose absorption, less and less movement water is used, until, in a short time, it can be stopped altogether, since the rate of sucrose absorption by the new enlarged crystals now equals or exceeds the rate at which it can be made available by evaporation. From now on the condition is no longer critical.

Another method in quite general use is to lower the vacuum, thus raising the temperature, and decreasing the supersaturation without using movement water, until the crystals have grown sufficiently to absorb sucrose as fast as it is made available by evaporation. This sudden increase of temperature is usually supplemented by giving the strike a "drink" of light syrup, further to reduce the supersaturation during this difficult period. This is the usual procedure after the waiting method and also after shocking. It may also be used after seeding. The technique varies with locality and tradition. It is definitely objectionable to feed water into the strike, as it has to be evaporated for nothing, and locally may dissolve some of the fine grain.

Mechanical circulation produces movement without evaporation, and here it is possible to "hold everything," allowing the circulator to operate with steam cut off and vacuum fixed, if necessary, until the required preliminary crystal growth has been obtained. In fact, with control instruments, the advisable thing to do is to hold the vacuum steady and adjust the steam supply to maintain the supersaturation at the desired point. Particular care must be exercised in the control of the vacuum, as a change here is immediately followed by a change in temperature, and hence a change of supersaturation. False grain is sure to appear if the temperature is lowered while the strike is in this critical state.

There is some diversity of opinion as to the best plan to follow after this grain preparation has come beyond the critical stage. Some advise not to carry the strike too "tight" on the assumption that tightening it will increase the supersaturation, and, therefore, bring out the false grain. We are decidedly in favor of tightening the strike, and this is one of the reasons why this paper was written. The explanations follow:

WHAT HAPPENS WHEN A STRIKE IS TIGHTENED

In a recent paper[1] a fairly detailed discussion was given of what happens when a strike of sugar is "brought together." It is quite appropriate to review some of the points brought out bearing strongly upon this discussion. Very accurate instruments were used in profusion, and it was possible definitely to establish the following points:

When the strike was brought together

(1) The boiling-point rise went down, as did the supersaturation.

(2) The rate of evaporation increased more than 40 per cent.

There is a definite limit in bringing the strike together, which must not be exceeded. If this limit is passed, the strike becomes so stiff that circulation is impeded, and evaporation retarded. It has been well established that for high-purity strikes the reactions just stated invariably take place.

There is a delicate point in the transition of physical conditions while the strike is being brought together. Apparently, the crystals will absorb sucrose much faster when they are close together. Not only will the growth be faster, but the danger of forming false grain practically disappears. It must be restated that the critical point must not be exceeded. The only accurate way to determine this is by the use of a steam-flow meter attached to the supply of heat to the pan. When this instrument shows a maximum steam flow, that is the right point and the best point for the strike.

BALANCE BETWEEN HEAT SUPPLY AND CRYSTAL GROWTH

Going back to the matter of crystal surfaces which determine the rate at which sucrose can be absorbed from the syrup, consider the example given at the beginning in which it was shown that total surface of the sugar crystals at the end of the strike was 361 times as great as it was when the pan was seeded. A

[1] "The Design and Use of Vacuum-Pan Control Instruments," by A. L. Webre, *Industrial and Engineering Chemistry*, vol. 27, October, 1935, pp. 1157–1161.

natural question would be to ask what influence this fact has on the operation of the pan.

It is felt that when ideal supersaturation is maintained, maximum and most uniform crystal growth takes place. This supersaturation may be 1.15, 1.20, or 1.25, more or less, according to the purity. At a certain point, when the grain has been finally prepared, with this ideal supersaturation, a balance is obtained between crystal growth and the rate at which sucrose is made available in the syrup, which in general corresponds to the rate of evaporation. Soon, the possible rate of crystal growth exceeds the rate at which sucrose can be made available by evaporation, and toward the end of the strike the former exceeds the latter many times.

Under these conditions, the necessarily decreased rate of crystal growth brings about an automatic reduction in the supersaturation of the syrup between the crystals, as this is the only way the balance can be established. It easily explains the reason why the strike is brought together and the rate of crystal growth increases the boiling-point rise, and hence the supersaturation, decreases. This, in turn, decreases the viscosity of the syrup, and hence permits an increased rate of evaporation, other things remaining the same.

As was mentioned in the reference,[1] the controlling factor is no longer the supersaturation, but the fluidity of the mass as a whole. This fluidity is a function of the ratio between the volume of the voids between the grains of sugar and the volume of the syrup in the pan and is not necessarily a function of the concentration of the syrup or of its viscosity—a very interesting conclusion indeed, and one to which consideration must be given.

CONDITIONS FOR CRYSTAL GROWTH

No one is justified in assuming that ideal conditions for the growth and development of sugar crystals are obtained in the average vacuum pan. It is necessary to face the facts and analyze them.

Fundamentally, it is known that crystals grow in a supersaturated sugar solution. This supersaturation can be increased in two ways, namely, by evaporation of water or by lowering the temperature. Conversely, it can be reduced by diluting with water or by increasing the temperature. Any two of the four reactions may be combined with corresponding results, except heating and cooling.

Let us consider what are the ideal conditions for satisfactory crystal growth, after which the pan operating conditions can be examined to see how closely the requirements are met.

In the first place, the supersaturation must not exceed the limits set for the purity of the syrup being used, otherwise, the growth of the crystals will be retarded and there is danger of forming false grain.

In the second place, in no part of the pan at any time must we have local conditions of unsaturation, as in this case the crystals already formed will dissolve in the syrup.

In the third place, for uniform and rapid growth, there must be considerable motion in the mass. Since sucrose is absorbed by the surface of the individual crystals, the tendency is for the film next to the crystals to approach saturation at which sucrose absorption ceases, so that this film must be changed and replaced by new rich syrup if growth is to be maintained. This is true with high-purity syrups, and much more so if the purity is lowered, in which case the unabsorbed impurities insulate the crystals from contact with available sucrose and make further accretion difficult, if not impossible.

This establishes the necessity of uniform conditions as regards concentration of syrup and movement of the mass, and no such conditions are to be found in either coil or calandria pans of the average design. It has been established[2] beyond any doubt whatever that temperatures in vacuum pans are subject to unbelievably severe variations during even carefully controlled operation. The magnitude of these local temperature variations is of the order of 50 F, or even more under bad conditions. Of course, it can be easily shown that if syrup at a normal supersaturation of 1.20 in a panful of massecuite is heated 50 deg, it will be much below saturation, and Table 1 will give a fair idea of the extent of the change.

A study of this table shows that an increase in temperature of 25 deg will practically bring the concentration of the syrup right down to saturation, and anything above this will bring about a condition of unsaturation wherein sugar will redissolve into the syrup. In view of the data brought out in the beginning, it will be realized that for the largest part of the strike the supersaturation is probably not more than 1.10 and may be even less than that. If such is the case, fluctuations in temperature will be much more harmful, in that an increment of only 12 deg will remove all supersaturation.

TABLE 1 SHOWING THE EFFECT OF TEMPERATURE INCREASE ON MASSECUITE SUPERSATURATED AT 1.20

(For normal supersaturation 1.20, new supersaturation for increases of temperatures)

Theoretical temp, F	10 deg	20 deg	30 deg	40 deg	50 deg	60 deg
120	1.14	1.08	1.02	0.94	0.89	0.83
130	1.13	1.07	1.00	0.94	0.87	0.81
140	1.13	1.07	0.99	0.93	0.86	0.78
150	1.13	1.05	0.97	0.91	0.84	..
160	1.13	1.05	0.97	0.89	..	..
170	1.12	1.03	0.93	..	..	..
180	1.11	1.02	..	..	..	..

Since these conditions are purely local, it is evident that some crystals will suffer and others will not, making for size irregularities, not to mention local increase of syrup concentration due to the dissolution of already crystallized sucrose. This latter condition can cause bad results when the mass reaches the surface of ebullition, for the supersaturation will suddenly become excessive, locally, resulting in false grain, conglomerates, molasses inclusion, and what not.

It must be emphasized that these conditions are in no way exaggerated. They actually exist and can and have been observed, as has been pointed out in another paper.[3] Since it is known that ebullition takes place far below the surface of the massecuite, at such points temperatures are reached which correspond to the reduced vacuum due to the superposed hydrostatic head, and this would easily account for variations of the magnitude mentioned above.

When all this is fully appreciated, it is a wonder that it is even possible to make satisfactory sugar in many vacuum pans of what has generally been considered standard design.

Turning back now to the question of movement of the crystals in the mass, further elaboration is necessary. In the ordinary pan all movement is due to ebullition which is really what causes circulation. Temperature conditions have little to do with movement, except in so far as they bring about the formation of bubbles of vapor under the mass. In other words, circulation is caused by boiling. It is interesting to note that at the locus of the heating surface there is either ebullition and motion, or absence of ebullition and stagnation. With ebulli-

[2] "Circulation in Vacuum Pans," by A. L. Webre, Trans. A.S.M.E., 1929, pp. 913–922, paper PRO-56-1.

[3] "Temperature Conditions in Vacuum Pans," by A. L. Webre. Presented before a meeting of the International Sugar Technologists, at Brisbane, Australia, in August, 1935.

tion, the temperatures existing at these points must be high enough to correspond to the boiling temperatures due to the reduced vacuum, which is simply another way of proving the inevitable presence of local hot spots. This cannot be avoided if operation is to go on, and for that reason, until recently, it has been found necessary strictly to limit the height of the strike above the lowest heating surface in order to avoid these excessive local temperatures.

It is a quite well-known characteristic of vacuum pans that they boil much slower as the strike is higher, and hence the motion is most sluggish when the danger of overheating is greatest, thus vitiating the entire cycle. Our tests on standard raw-sugar vacuum pans have shown the following, for strikes about six feet above the heating surface:

Type of strike (14 ft)	Maximum evaporation, lb per hr	Minimum evaporation, lb per hr
"A" (80 pur.)	30300	15250
"B" (70 pur.)	23900	12600
"C" (58 pur.)	17850	1150

(Note that the worst variations are for the low grades, the most dangerous strikes.)

MECHANICAL CIRCULATOR PERFORMANCE

In reality it was as a result of these pan investigations that we decided it was practically impossible to approach ideal conditions with natural circulation in vacuum pans. It is not claimed that the mechanical circulator enables us to operate under perfectly ideal conditions. However, the operation has been so greatly bettered that a radical improvement has been achieved.

Whereas there are still observable temperature variations, their magnitude has dwindled down to negligible proportions, thus minimizing the ill effects outlined. The complete elimination could only be accomplished at an altogether unjustifiable expense.

The motion of the massecuite is at a certain definite constant rate independent of the rate of evaporation, the purity of the massecuite, the steam pressure, or the vacuum. It is governed simply by the volumetric displacement of the circulator. As far as movement is concerned, it is adequate for all practical purposes, and under complete control.

As regards the influence of height of the massecuite on the making of the strike, this has completely disappeared, and perfectly good strikes are being made as high as 14 ft above the top of the heating surface.

The most remarkable feature has been the maintenance of substantial uniformity in the rate of evaporation from the beginning to the end of the strike, another large step toward the absence of variations so desirable for the proper elaboration of massecuite.

Sugar-fabrication men are quite familiar with the characteristic sluggish operation at the end of the strike when it is brought together. This feature also has almost disappeared. High-purity strikes come together in about three minutes, whereas low grades take proportionately longer.

Greatly increased heat transmission brought about by proper mechanical circulation makes possible the use of juice vapors at low temperature, even under partial vacuum. This not only effects a large steam saving, but allows the making of strikes with a minimum of heat injury.

The most significant gain, however, is in the uniformity of size and shape of crystals. From the viewpoint of the raw-sugar factory, it is well known that bad grain invariably results in sugar of low filtrability, and hence undesirable and of poor marketing value.

From the standpoint of the refinery, uniformity of size and shape of crystals is still more important. Irregular shape and lack of uniformity produce sugar which becomes lumpy and unsalable, even after moderate storage. Furthermore, due to lack of heat injury, the color of the sugar is always white, and serious losses by temperature inversion are avoided.

These results are directly attributable to the use of the mechanical circulator.

Nesmith

OCCUPATIONAL DISEASES

Additional Responsibility Legislation Places On Industry

By HENRY D. SAYER

ASSOCIATION OF CASUALTY AND SURETY EXECUTIVES, NEW YORK, N. Y.

NOT many years ago legislators and industrialists responded to the new doctrine of compensation for industrial accidents without regard to fault as a causative factor. So familiar has this compensation principle become that it is virtually unanimously accepted by employers, and this idea that was so revolutionary only a short twenty years ago is now an accepted rule of industry. Its burdens have not been lessened as time has passed. On the contrary, compensation costs have steadily mounted. But industry long since learned to absorb those costs and to assume those burdens, even though frequently at the cost of great hardship.

Entirely aside from the monetary benefits to injured workers and the dependents of deceased employees, the two great outstanding benefits to workers through the compensation system are (1) the reduction of accident frequency brought about by the promulgation of safety standards and by good engineering, and (2) the reduction of accident severity, by the requirement for prompt medical and surgical care at the expense of the employer. These are the positive sides of compensation for accidents, and employers may well take pride in the accomplishments of industry, of medicine, and of engineering in these lines.

RECENT LEGISLATION ON OCCUPATIONAL DISEASES WIDESPREAD

Just as twenty years ago there was the insistent demand for compensation for accidental injuries, so now there is an ever growing demand for legislation for compensation for industrial diseases. This is no new thing to us here in New York. We have had an occupational-disease statute since 1920. Three or four other states have rather full occupational-disease laws, while some others have laws of somewhat limited application. But in the greater number of states, no provisions have been adopted for compensation for occupational diseases.

The essence of the idea of compensation for occupational diseases is that disability or death from a truly occupational disease is just as much the responsibility of industry as is such a condition resulting from industrial accident.

With this principle it is hard to disagree. Few there are who will say that the workman who suffers a disability, who is deprived of the means of a livelihood through a disease or sickness that came upon him only because of his exposure in his work to the deleterious effects of some poison or some chemical, some dusts, gases, or fumes, is not equally entitled to compensation with his brother whose disability came on him by reason of an accident. In principle both seem alike.

So prevalent is this idea that in the legislatures of 18 states bills were introduced last winter newly providing for occupational diseases or for enlarging the existing laws. In a number of states provision was made for the appointment of interim legislative committees to study and report on the subject of occupational-disease legislation at the next sessions. Undoubtedly, another year will see legislative attempts in many more states. In great part these efforts were not successful, but a renewal of them is inevitable.

Employers will have to prepare to meet the added burden of such laws. Just as in time the cost of compensation for accidents was absorbed, so too will the cost of compensation for diseases in time be absorbed if right principles prevail and if the effort is not made under the guise of compensation to charge employers with general health and life insurance of their workers.

But it is not certain that correct principles will always be observed. The temptation is great to give to the oppressed and distressed—out of the other man's funds! To be the public almoner of industry's money must be a comforting thought to some public officials—especially at election time.

NECESSARY TO SAFEGUARD AGAINST ACCRUED LIABILITY

We must, therefore, be vigilantly on guard to demand in all such legislative efforts a recognition of sound principles and policies, and insist that such laws do not throttle the industry itself. It is essential that we insist on at least two safeguards: (1) To guard against the already accrued liability, and (2) to make certain that compensation shall be payable only for diseases that are truly occupational.

What is meant by the term accrued liability is illustrated by what has recently happened in New York. The New York state law is what is known as a schedule law, that is, the law itself contains a list of diseases or poisonings with a parallel column listing the occupations or processes in which such conditions usually occur. Thus, to use a common illustration, lead poisoning is listed as a disease, and is compensable when incurred by a worker engaged in any work that causes him to use or be exposed to lead. This, it will readily be seen, is truly an occupational disease, readily recognizable as such, and is a definite pathological entity. Seldom is the disease found except among lead workers, painters, and the like.

The schedule in the New York act had been enlarged from time to time until it included practically all known occupational diseases with the exception of lung diseases attributable to dust. It is generally conceded that these dust diseases call for special provisions of law and for different procedures. The effort to provide such special provisions proved abortive, and when the legislature passed a general all-inclusive provision to cover in broad terms "any and all occupational diseases," it swept in under the law all dust diseases along with the rest.

SOME OCCUPATIONAL DISEASES ARE OF SLOW DEVELOPMENT

Now by the very nature of these diseases they are of slow, progressive development. Silicosis, or a fibrous condition of the lungs resulting from the inhalation of silica dust, requires a minimum of five years of exposure to produce disability, and many authorities assert that the progression to disability takes from ten to fifteen years. In all these diseases, there comes a time when regular work is not possible. This is called in the

Contributed by the Safety Committee and presented at a session on Occupational Diseases at the Annual Meeting, New York, N. Y., Dec. 2–6, 1935, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Slightly abridged.

law "disablement." The moment the wide-open law went on the statute books, it created a liability for many years of exposure that had already taken place among thousands of workers. Industry found itself faced with the problem of paying for conditions that arose at a time when the law imposed no special duty on the employer to pay for the condition or to take effective measures to prevent the disease.

While industry cannot assume safely such a burden, neither can insurance be asked to take it on. Payment for losses that accrued prior to the insurance contract is not in any sense insurance; insurance is the assumption of liability for a contingency or for a fortuitous future happening.

The result of the new law in New York has been disastrous. Premium rates were set at prohibitive figures. Where dust exposures existed supplementary rates were added to the regular already high compensation rates. These supplemental rates ranged from the lowest at something more than a dollar per hundred dollars of payroll up to as high as twelve and thirteen dollars a hundred. The total compensation cost, therefore, for many industries has risen to more than twenty dollars. When this is compared to the comparatively low compensation cost in states where such liabilities have not been imposed on industry, it will be readily appreciated how difficult it is for New York industries to survive under competition. Since September 1, 1935, the effective date of the new law, many plants have utterly closed down, some have gone on part time, others are contracting out to plants in other states that part of their operations which are involved in dust, and with it all, the worker may be said to be the sufferer through unemployment.

Any attempt anywhere to impose on employers by law a burden of responsibility for diseases of past contraction will lead inevitably to such a muddled situation as exists in New York today.

COMPENSATION SHOULD BE CONFINED TO TRULY OCCUPATIONAL DISEASES

The second principle is that compensation shall be provided only for diseases truly occupational. The term "occupational disease" is in common use, yet it has no fixed definition nor definite limitations. The effort is sometimes made to define it as a "disease that arises out of and in the course of employment." Such a definition is thoroughly unsatisfactory. This terminology has been used probably because it has ample precedent in the field of accident compensation, but the conditions surrounding accidents and those surrounding disease are so radically different that the same terms will not do.

Shall we say that heart disease, tuberculosis, pneumonia, pleurisy, head colds, and all the multitude of human ills shall be deemed occupational when they occur among workers and it is claimed that some act or incident of the employment caused or contributed to the disease? If so, it means nothing less than general health and life insurance for workers at the employer's expense. This is not a burden that industry should or could bear.

An occupational disease is not a disease of ordinary life, but a disease "characteristic of and peculiar to" the occupation. When speaking of disease, these words are far more definite than is the phrase "arising out and in the course of" employment. They should be used wherever it is impossible to have a schedule or listing of diseases.

This qualification has received the approval of the State Industrial Board in New York. As yet there has not been sufficient time for a case to arise under it and be passed on by the courts, but it is greatly to be hoped that the courts will follow this view of occupational diseases.

There is another, and to engineers a very important, consideration in favor of the schedule method of covering occupational diseases, rather than the general all-inclusive method, and that is prevention. Prevention is the key to the occupational-disease situation. Just as the engineers took up the challenge in the field of industrial safety when accident-compensation laws came into operation, and have done a magnificent job, so they will have to take over an intensive study of the means and methods of prevention of disease. They have learned that good results are obtained only when they can concentrate on some special problem or on some phase of a problem.

How better can the engineer concentrate on occupational-disease prevention than to start out with a named list of diseases set forth in the law? It is often necessary to appeal to employers or management to take certain steps in throwing up safeguards, and these cost money. If the engineer is dealing with a definite schedule of diseases he looks for the conditions in a plant from which those diseases may arise. He can tell management that if lead is used workers must be safeguarded from it. That is elementary. But without the law suggesting it, how many would think to guard against chrome ulceration, or adequately safeguard workers coming in contact with or using methyl chloride, or any of the other many conditions included in the occupational-disease schedule?

SAFEGUARD AGAINST EVERYTHING

It may be suggested: Safeguard against everything. However, no matter what attempts are made, no matter how willing the employer to go along with the plans, under any blanket plan some dangerous conditions will certainly be overlooked.

And from the standpoint of bringing to the employer the necessity of spending money in disease prevention, it is hard going to convince him that he has a disease hazard warranting the expenditure of large sums unless the law gives the clue to the diseases to be guarded against. Only by the slow laborious process of picking up diseases as they occur and are made compensable over a period probably of years will we get effective prevention work, unless the scientific knowledge of diseases and industrial processes now possessed by public authorities in the field of industrial hygiene is made available to industry through writing it into the statute.

That new burdens are being imposed on employers by recent legislation or are impending in the demand for new legislation must be recognized. There will be no turning back in this field, any more than there will be turning back in the field of compensation for accidents. If, however, we are wise, we will give heed to the lessons we have learned out of an abundant experience in accident compensation. The same motivating factors will be present in this new field; the same liberality, the same generosity with the employer's moneys. The cure for all the workers' ills will be attempted through these laws. Vagueness and lack of definition but play into the hands of the overliberal.

We should insistently demand that occupational-disease legislation be intelligent, certain in terms, and properly safeguarded against already incurred liabilities. Let the employer's responsibility be expressed in understandable terms and with a scrupulous regard for the ability of industry to carry the increased load. And above all insist that the law be so worded as to make effective prevention work possible. By so doing, and only by so doing, will industrial justice be done and effective steps taken to carry industry's part in the field of the true occupational disease.

Engineering Control of OCCUPATIONAL-DISEASE HAZARD

By WARREN A. COOK

CONNECTICUT STATE DEPARTMENT OF HEALTH

IT IS the purpose of this paper to outline a practical procedure which the engineer can employ in his own plant to assist in the control of occupational-disease hazards. The solution of the occupational-disease problem is by no means a one-man job; it requires the active cooperation of all concerned, the engineer playing a large part in its successful solution. He is more than an important cog in the wheel; he is a vital center in the mechanism for control of industrial health hazards.

The mechanism to be set in motion for provision and maintenance of healthful working environment is, within limits, much the same whether the engineer is associated with a large manufacturing organization or with a small unit.

The first step for the engineer to take is to ascertain just what hazardous materials, processes, and conditions exist in his plant. We all know generally that a variety of organic solvents are used in spray lacquers and thinners, that grinding wheels are made up of various types of abrasives. But such generalized information is not sufficient. It is essential that the engineer know specifically every potentially hazardous material used in his plant.

LIST THE MATERIALS THAT ARE HAZARDOUS

This then is the first item of the practical procedure to follow: Go through the plant, department by department, and list the materials used in or given off by each operation. You may be of the opinion that you know all these items as part of your intimate knowledge of the plant. But it has been our experience when making plant surveys that there are usually a number of gaps in the engineer's knowledge of these materials.

Do you know, for example, whether the thinner used in your plant contains benzol as a constituent, whether gasoline for nonfuel purposes is free from lead, whether sandstone grinding wheels are employed, and what abrasives are used on made-up wheels or disk grinders? A complete survey of plant conditions will disclose such information and provide information on the potentially hazardous materials with which you have to contend.

Since new materials are constantly being introduced, have a standing arrangement with the purchasing department to keep you informed of any such materials ordered. If it is decided to substitute methanol for denatured alcohol, it may not be necessary to make any mechanical changes in a process and you may not be notified of the substitution. But you should know that this more hazardous solvent has been introduced, as additional control measures may be required. One of the surest methods of keeping your permanent record up to date is to have the purchasing department transmit this information to you.

Of assistance in compiling the list of injurious materials used in the plant is the bulletin, "Occupation Hazards and Diagnostic Signs," prepared by Dublin and Vane.[1] This bulletin presents a list of hazardous occupations and the injurious materials and conditions which may be associated with them. The potentially hazardous materials to which workers were exposed in a group of plants in a typical industrial area are listed in the report[2] of a survey recently conducted by the United States Public Health Service. This report includes the number and percentage of workers exposed. It may also assist in compiling the list of such materials used at your plant.

The permanent record of the potentially hazardous materials and the operations with which they are associated may well be compiled in the form of the potential-health-hazard chart prepared by our bureau, in which the injurious materials are listed along the abscissas and the industrial classifications along the ordinates of cross-section paper. In the chart which you make up for your plant, the individual departments and operations will be substituted for the industrial classifications. The information given by this chart may be made more complete by inserting, instead of the X used in our chart, the number of workers exposed together with a symbol to indicate the relative severity of the hazard.

LEARN WHAT PROPERTIES OF HAZARDOUS MATERIALS AFFECT HEALTH

Having made a complete permanent record of the materials used, including their constituents, and of the departments and occupations where they occur, be sure that you are informed on the properties of these materials which affect health. You should know relatively how much of the material is required to cause injury and, generally, how the material affects the body. You should be sure that your information is reliable and that it is in accordance with up-to-date knowledge and opinion. Research on this subject is continually being conducted and our knowledge of the injurious action of these materials extended. Occasionally, erroneous impressions of the hazards presented by various materials gain credence and must be corrected.

Some years ago the textbooks stated that pneumoconiosis was caused by sharp-edged dust particles such as those of granite and aluminum oxide. It has since been shown that the sharpness or hardness of the dust particles is not the criterion of their pneumoconiosis-producing properties and that workers exposed to sufficient concentrations of quartz dust to cause pneumoconiosis do not develop this condition when exposed to similar concentrations of equally hard and sharp-edged aluminum-oxide dust. Many engineers have a good conception of the types of dust which are most injurious, but erroneous impressions come to light when industrial health hazards are discussed. For example, we often find that the engineer fails to recognize that carbon tetrachloride is injurious on its own account but has the misconception that only its products of hydrolysis when used in extinguishing fires are hazardous; and again that toluol is noninjurious since it was recommended

[1] U. S. Bureau of Labor Statistics Bulletin No. 582, 1933.

Contributed by the Safety Committee and presented at a session on Occupational Diseases at the Annual Meeting, New York, N. Y., Dec. 2–6, 1935, of The American Society of Mechanical Engineers.

[2] "The Potential Problems of Industrial Hygiene in a Typical Industrial Area in the United States," by Bloomfield, Scott, and Sayers, Public Health Bulletin No. 216, December, 1934.

as a substitute for the more toxic benzol. The facts are that all the organic solvents are toxic, though to varying degrees. So although you cannot expect to know the whole subject of industrial toxicology, it is important that you be reliably informed on the injurious properties of the materials used in your plant. Such information can be obtained from some of the recent general references on the subject, or, even better, from such sources as your plant physician, federal and state bureaus of industrial hygiene or occupational diseases, insurance engineering departments, universities, and private consultants.

DETERMINE WHICH POTENTIALLY HAZARDOUS MATERIALS, PROCESSES, AND CONDITIONS ARE ACTUALLY CAUSING INJURY TO HEALTH OF THOSE EXPOSED

The third step in the procedure of controlling occupational-disease hazards is to decide which of the potentially hazardous materials, processes, and conditions are actually causing injury to the health of those exposed. These potentially hazardous conditions will fall into three categories: Those obviously requiring control measures, those which may be considered negligible, and those which require determination of the exposure to show whether or not the potential hazard may actually be affecting health.

The use of determinations of atmospheric contaminants has been emphasized in the Connecticut Bureau of Occupational Diseases as an exceedingly satisfactory basis on which to proceed. Engineers are trained to work from facts; the results of determinations of injurious materials in the air are the fundamental facts in occupational-disease control.

The following experience shows what can happen when information is lacking concerning the exposure of workers to potentially hazardous conditions. Eighty men were connected with a department in which two machines involved the use of one of the newer organic solvents that had been shown to be only moderately toxic. Eleven of these men were directly engaged in the operation of the machines. The process had been in use for some time when an alteration was made which increased the concentration of the vapor and duration of exposure of the workers. Even with the increased concentration of the vapor, the odor was not unpleasant nor, as far as we know, did it cause the workers to complain.

Within a fortnight, one of these 11 workers, a normally healthy young man, 29 years of age, went home after the extra long Sunday shift of 12 hours feeling ill. He died six days later, the cause of his death being attributed to influenza and dilated heart. No cause-and-effect relation was linked at that time between his occupation and his death. On the Sunday following, a second man working at these machines was taken ill, and on the next day a third. Cases 2 and 3 were still ill when two more workers were transferred from workroom to hospital; and within 14 days from the death of the first victim, five workers had succumbed to fatal poisoning.

The point of this illustration is not that the organic solvent was extremely poisonous nor that it should necessarily be replaced by some less injurious material. There is no question but what the process, employing the very same solvent that caused the deaths, could have been conducted in such a manner as to cause no injury to health. The point is that the engineer in charge of the operation did not recognize his responsibility to ascertain definitely whether the exposure to the solvent vapor was within safe limits. Had vapor determinations been made at the time the process was changed, the hazard could have been controlled before the injury to health occurred.

Materials of equal or greater toxicity are being used in many plants today. If any change is made in an operation or in the material used, ascertain that such change does not increase the hazard beyond safe limits. Only by knowing the hazards and determining that the exposure to them is within safe limits can you be assured that your plant will not be visited by any such lamentable occurrence.

Not only do determinations of these atmospheric contaminants show where control measures must be instituted but, in other instances, they may permit appreciable saving by showing that control measures involving expensive exhaust equipment may not in every case be necessary. Illustrative of such a situation is the potential hazard from the lead melting pot.

For years there has been a tendency to recommend exhaust ventilation over melting pots containing lead and its various low-melting alloys in slush casting and linotype-machine operation. To determine just how necessary it is to have hoods over the melting pots of type-setting machines, air analyses were made in connection with an investigation of health hazards resulting from the use of these machines.[3] The results of these analyses showed that the daily exposure where there were no exhaust hoods was less than 0.2 mg. Studies made by our bureau where no local exhaust was applied to the linotype machines have also shown lead concentrations of this same order, well below the amount which causes poisoning. In studies conducted in lead-casting departments of four plants during the past year, we found the exposure of the casters to vary from 0.1 to 0.5 mg of lead per 10 cu m of air. The amount of lead collected in samples taken directly over the melting pots varied from less than 0.1 mg to less than 0.4 mg per 10 cu m.

Since it has been well established that except for prolonged exposures the limit of safety under most industrial conditions is an atmospheric concentration of lead dust or fumes of less than 1.5 mg per 10 cu m of air, the foregoing determinations indicate that there are more important control measures than the provision of exhaust ventilation for lead melting pots kept at moderate temperatures.

Of interest in this regard is a table of the calculated maximum lead-vapor content of air over surfaces of lead kept at various temperatures from 250 C to 1500 C which was published in the foregoing paper.[3] A portion of this table is reproduced in Table 1.

TABLE 1 CALCULATED MAXIMUM LEAD-VAPOR CONTENT OF AIR OVER SURFACES OF LEAD KEPT AT VARIOUS TEMPERATURES

Temperature C	Temperature F	Concentration of lead, mg per 10 cu m
300	572	0.00006
350	662	0.0016
400	752	0.02
450	842	0.2
500	932	2.0

From this table it will be noted that the temperature must exceed 900 F before injurious concentrations of lead vapor are given off from the melting pot. A warning should be given, however, that as the temperature exceeds this value the amount of lead vapor evolved from the surface of the molten lead increases rapidly; when the temperature doubles from 500 C to 1000 C the equilibrium concentration of the lead vapor above the surface of the molten lead increases 50,000 times.

Since things are not always what they seem, even when considering such a prosaic entity as occupational-disease hazards, the engineer should have information on the amount of the injurious substance to which the worker is exposed wherever there is a possibility of doubt. Determinations of atmospheric contaminants bring to light hazardous conditions before occu-

[3] "Hygiene in Setzmaschinenräumen," by Vaje and Weber, Schriften aus dem Gesamtgebiet der Gewerbehygiene, no. 44, 1935.

pational diseases develop. In former years the only criterion of the healthfulness of the industrial environment was whether or not clearly demonstrable injury to health occurred. And usually it was necessary for several cases of occupational disease to develop before the working conditions were accepted as the aetiological factor.

Utilize the methods available today to keep one step ahead of the occupational-disease specter. Determine whether the working conditions are safe or hazardous on the basis of the concentration of the hazardous material present. If the worker is exposed to more than the threshold dose, then act at once to correct the condition. It is not necessary for the engineer to delay, fearing that he may be overestimating the severity of the hazard and so letting his concern in for unessential and unproductive expenditures; he can stand behind his recommendations when they are based on facts which show the hazard to be excessive. It has been our experience that the engineer armed with such facts has received support from the management such as had previously been accorded him only on projects which offered an assured production profit.

APPLY ENGINEERING PRINCIPLES TO KEEP WORKER'S EXPOSURE WITHIN SAFE LIMITS

This leads to the fourth step in the procedure for the control of occupational-disease hazards: The application of engineering principles to keeping the worker's exposure to potentially hazardous conditions within safe limits. As stated by Clark and Drinker in their new book,[4] "Prevention of industrial disease is largely an engineering problem, as its basis is a separation of the toxic or irritating substance from contact with the worker."

This separation of the harmful material and the worker may require application of the most ingenious engineering skill or merely of simple engineering principles, but in either case there should be a generous portion of that most valuable quality, the ability to be practical. General methods of occupational-disease control measures can be divided into a number of groups, such as provision of enclosures, exhaust ventilation (both local and general), changes in process (dry to wet, for example), substitution of more toxic by less toxic materials, and wearing of special protective equipment.

Without going into examples of each of these general methods, consider from an industrial-hygiene point of view some simple operation, such as sandblasting. Assume that this operation is conducted in a modern, specially designed room, that the sandblaster is equipped with a positive-pressure helmet, that a steel abrasive is used, and that a cloth-filter type of dust collector is provided. It may perhaps be felt that the condition can be dismissed as completely satisfactory.

But is the sandlbaster adequately protected? Let us see just what should be taken into consideration to assure that an affirmative answer can truly be given.

The dust to which the sandblaster may be exposed comes from two sources, that in the sandblast room and that in the air line to his helmet. If there is an appreciable amount of molding sand on the castings being cleaned, the dust in the room will contain free silica, though the percentage will be considerably lower than if a sand abrasive were being used. The positive-pressure helmet may look good on paper, but examine it on the man to make sure it permits no easy access for the dust. With some types of helmets there is a strap or elastic which permits a tight fit around the neck. Does the sandblaster so adjust this that the dust cannot enter the breathing space? Or perhaps there is an opening at the front of the helmet when he leans over in the course of his work. The velocity of the dust is so great during sandblasting that it will find its way into the helmet if there are openings of appreciable size even against the stream of air escaping from it.

Having ascertained that the helmet fits properly and is so adjusted that the dust does not have access to its interior, turn your attention to the air supplied in the positive-pressure line. How much dust does it contain? Is the intake of the compressor so located that the air is clean? Even when an air washer is supplied we have occasionally found this to be ineffective if dust has been allowed to accumulate in it or if the water has evaporated or the glass cracked. And is a sufficient volume of air supplied? Does the valve on the air-supply line permit the sandblaster to reduce the volume of air below that necessary to make the helmet as effective as its manufacturer designed it to be? Possibly the air line contains some oil from the compressor and the blaster may shut off the air to avoid the discomfort at the expense of subjecting himself to a severe health hazard. Provide the man with a clean air supply and be sure he is getting the proper volume of it.

Having checked these items, make a dust determination of the blaster's exposure while conducting operations in the usual manner. A determination of the free-silica content of the dust will assist in the interpretation of the result. But a good helmet will keep the exposure well below five million particles per cubic foot of air which is considered good performance whatever the free-silica content.

After the actual sandblasting has been completed, are there other dusty operations which the blaster may include as a part of his duties? An approved filter-type respirator should be worn while performing incidental jobs involving moderately excessive dust exposures.

Perhaps one of these jobs is emptying the dust collector two or three times a day. In one case we made dust determinations of the blaster's average exposure while transferring the dust from the hopper of the collector into barrels and found it to be 324 million particles per cubic foot of air! Even this represented an improvement over a former condition since a canvas cover had been provided which extended the canvas discharge tube so that it fitted over the top of the barrel. At the plant where this determination was made, the blaster was exposed for ten minutes twice a day to this high dust concentration.

It is essential not only to keep the average exposure within safe limits, but also to avoid exposures to greatly excessive concentrations for even brief periods. The importance of avoiding such exposures is not limited to dusts but also applies to many other injurious materials found in industry, especially where the brief exposures are repeated day after day.

There are several methods for removing the dust from the collector without subjecting the worker to large amounts of it and some effective method should be utilized. In problems of this type the engineers of the equipment manufacturers are of much assistance.

A survey of the sandblast operation should include exposure of other workers in its vicinity. Is the sandlbast room itself tight? Where is the dust collector discharged? There has been much discussion concerning the discharge of cloth-filter dust collectors back into workrooms where free silica is one of the constituents of the dust. The final answer to this question depends upon the ability of the engineers of the equipment manufacturers to provide a collector which will clean the air sufficiently and with such certainty when all operating factors are considered that the worker is not exposed to an injurious atmosphere.

The difficulties of dust suppression, the limitations of dust collection, and certain other factors cause the preponderance of

[4] "Industrial Medicine," by Clarke and Drinker, National Medical Book Co., New York, N. Y., 1935.

opinion at the present time to favor the discharge at a point outside the plant of air from collectors handling a dust of high silica content. However, in a particular plant under certain circumstances, it may be especially desirable to return the air from the collector to the workroom. If this is done, then by all means ascertain by dust determination that those employed in the workroom are not exposed to excessive dust concentrations, and further, institute a rigid routine of maintenance and check dust determinations to assure yourself that the dust exposure is being kept within safe limits.

INSTITUTE ROUTINES OF MAINTENANCE AND CHECK-UP

The engineering control of any occupational-disease hazard cannot be attended to once and for all and then forgotten. Eternal vigilance, in the form of maintenance and check determinations of the atmospheric contaminants, is essential to the complete solution of the problem. This is the fifth step in the engineering control of occupational-disease hazards.

Maintenance is of such paramount importance in occupational-disease control that it should be made the subject of an entire paper. The following is an example of what can be done when such a piece of equipment as a dust collector is properly maintained under the direct supervision of the plant engineer. Dust collectors were connected to two sandblast-table rooms using sand abrasive. The collectors had been in continued use for six years. During this time they were thoroughly inspected and cleaned every month. Konimeter dust samples were taken at the discharge of the two collectors. These showed counts of 1.2 and 0.7 million particles per cubic foot of air for one of them, and, for the other, 3.1 and 2.8 million particles. A week later the second dust collector was checked with an impinger and a concentration of 2.35 million particles was found in the exhausted air. This collector had been cleaned and inspected about three and one-half weeks previously. Another impinger sample was taken within a few days after its next regular cleaning and the concentration at the discharge was found to be only 0.87 million particles per cubic foot of air. After another two weeks, opportunity was taken to collect still further konimeter samples at these two dust collectors and average concentrations of 2.3 million particles and 1.5 million particles per cubic foot of air were found. The engineer who maintained these dust collectors in such excellent condition deserves much credit, which the engineers who originally designed the equipment would gladly accord him.

Other pieces of equipment than dust collectors also require adequate attention to maintenance to assure that a health hazard once controlled will continue to be controlled.

CONCLUSIONS

A procedure has been outlined for the engineer to utilize in his plant as his part in the control of occupational-disease hazards.

(1) He should make a permanent list of the materials used in his plant and keep the list up to date.

(2) He should be informed concerning the injurious properties of the hazardous materials used.

(3) He should determine which of the potentially hazardous conditions are actually causing injury to health and should be controlled.

(4) He should engineer the control measures, preferably checking the completeness of control by determinations of the injurious materials in the air breathed by the worker.

(5) He should institute routines of maintenance and check-up determinations.

The manner in which this procedure could be followed was outlined in connection with the simple operation of sandblasting. This same procedure can be utilized for the control of health hazards of similarly simple operations or of the most complex operations where a variety of hazardous materials are involved. Every available aid should be made use of in coping with the occupational-disease problem to the end that the hazardous condition may be controlled before it manifests itself in the form of cases of occupational disease.

Photograph by John P. Mudd for the Midvale Company

FUNDAMENTAL FACTORS *in the* DESIGN *of* EXHAUST SYSTEMS

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BECAUSE of the widely varying requirements and limitations of the vast number of industrial processes to which local exhaust ventilation is applied, the American Standards Association Safety Code Committee for Exhaust Systems proposes to develop separate standard specifications for each industry rather than one inclusive code. Several subcommittees have been appointed or projected to deal with various industries. In addition another subcommittee, on fundamentals of exhaust systems, was formed whose function it is to formulate and arrange in useful form the basic principles of design common to all exhaust systems, which should be incorporated in the separate codes.

Most state exhaust codes are based upon a few empirical specifications which have not been changed in any important respect since their formation.[1] These specifications are being applied today to the design of exhaust systems for processes never considered when the codes were prepared. In many cases the results have not been satisfactory; but, on the other hand, some highly efficient systems have been constructed. In no case, however, have the systems been described in terms of basic engineering specifications, nor has it been general practice to test new installations to determine the degree of dust control effected. Since state codes required only the development of a definite amount of static suction, it was enough simply to check this value. Hence, the considerable experience gained in the design of exhaust systems has not been evaluated and systematized and made generally available to designing engineers. Personal experience still remains the principal guide to design.

Two steps are necessary to correct this situation: (1) Formulate and present in a systematic manner whatever fundamental concepts and data are available at the present time and indicate the manner in which these influence the method of design; (2) analyze existing systems critically and summarize the basic data pertaining to them in useful form. The adoption of fundamental methods of design and the systematic analysis of results accomplished are necessary in order to build up a body of technical experience to serve as a guide for future design.

The Subcommittee on Fundamentals of Exhaust Systems has attempted to assemble in ordered fashion the underlying principles of design and operation of exhaust systems and these are presented as a progress report for critical review.[2] The subject may be presented under five headings: Hoods, piping, air-cleaning plant, source of suction, and construction and maintenance.[3]

EXHAUST HOODS

In order to prevent the dispersion of contaminating material into the atmosphere, the force which causes the dispersion from the source must be destroyed or otherwise brought under control. The energy of dispersion is supplied in several ways.

I *Solid and liquid particles.*

(*a*) If the particles are large enough and are thrown off with sufficient velocity, they will be dispersed by the kinetic energy of their own motion, i.e., by dynamic projection. The energy supplied in this way varies with the size, specific gravity, and the initial velocity of the particles.

(*b*) Microscopic particles cannot be dispersed any distance by virtue of their own kinetic energy because of their relatively great air resistance and small weight.

(*c*) Microscopic particles are dispersed primarily by the movement of the air in which they are suspended.

II *Vapors and gases.*

(*a*) The maximum velocity of diffusion does not exceed 1 fpm and this is therefore an unimportant dispersing force.

(*b*) Vapors and gases lighter or heavier than air rise or fall, but the velocity of escape is not high unless there is a considerable difference in density. Gases escape from pressure containers with velocities that may be very high but such a source of contamination is best controlled by means other than exhaust ventilation.

(*c*) Vapors and gases escaping into the atmosphere at approximately the same density and temperature as the room air are dispersed primarily by air movement.

Thus, it may be concluded that the basic problem is to collect contaminated air rather than to remove the contaminating material from the air. This concept is important because it directs attention at once to the primary point of attack, namely, the source of air motion. It follows from this that prior to applying the exhaust hood every means must be taken to reduce the velocity of air movement around the process by eliminating or otherwise controlling the sources of air motion. There are numberless ways in which air movement is produced around manufacturing processes; the following classification of important sources is helpful:

(*a*) Motion produced inherently by the operation of the process itself. Examples: Air thrown off by the fan action of a rotating grinding wheel; escape of air from a container as it is filled with a powdered material.

(*b*) Air movement generated incidentally to the operation of

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[1] A notable exception is the Wisconsin code.

[2] For the organization of the subject matter, the subcommittee has drawn freely from the manuscript of a book: "Industrial Dust: Hygienic Significance, Measurement, and Control," by Philip Drinker and Theodore Hatch, to be published by McGraw-Hill Book Company.

Contributed by the Safety Committee and presented at the Annual Meeting, Dec. 2–6, 1935, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

A preliminary report by the Subcommittee on Fundamentals of the American Standards Association Committee on Code for Exhaust Systems: Theodore Hatch, chairman; M. I. Dorfan, W. M. Graff, Leonard Greenburg, J. C. Hardigg, H. M. Nichols, W. L. Keplinger, G. E. Sanford, R. R. Sayers, and S. E. Whiting.

[3] Criticism of the report and suggestions are invited, and should be sent to the Secretary, Subcommittee on Fundamentals, Exhaust Code Committee, American Standards Association, 29 West 39th Street, New York, N. Y.

the process. Examples: Escape of air past worn pistons on pneumatic tools; vibration of machinery.

(*c*) Drag of air in the wake of large particles dynamically projected from their source, as from a grinding wheel.

(*d*) External sources of air movement. Examples: Natural convection currents; motion due to the operation of nearby machines.

CONTROL OF AIR MOVEMENT

The best way to eliminate air motion generally suggests itself from the nature of the source. Thus, proper maintenance prevents air leakage around pistons. The vibration of machines is corrected by improved design and proper foundations. Relocating the exhaust port on a pneumatic tool directs the blast of exhaust air away from, instead of toward, the point of dust generation. A properly vented water seal on a digestion tank prevents the accumulation of excess pressure and sudden release of gas at high velocity. The scattering of dusty air from a container being filled with powdered material is most effectively minimized by using a collapsed container or by providing a suitable vent from the container to a safe point of discharge.

Air motion generated by the operation of the process itself can be eliminated in part by the application of suitable baffles and enclosures. Example: Locating a stationary disk as close as possible to the face of a rotating wheel materially reduces the fan action of the latter. The pulsating waves of air generated by a reciprocating part can be minimized by enclosing the part. In some cases, as with a rotating wheel, the housing can be designed to direct the air movement into the exhaust opening and thus utilize the energy of the air for its own collection.

It is impossible to eliminate all air motion by these direct means but such measures are of great practical importance. In general, more can be done in this way to reduce the size of the exhaust system, the power consumption, and the cost of operation than by the most elaborate method of hood design.

The exhaust hood creates air flow from the zone of generation of the contaminating material toward the exhaust outlet. At any point, the velocity thus established must be greater than the outward velocity of the contaminated air; that is to say, all air movement must be turned toward the hood. This is accomplished with any kind of a suction opening provided air is drawn into it at a high enough rate. The object of hood design, however, is to accomplish the desired result with the lowest possible rate of air flow. This requires a knowledge of the laws governing the flow of air into suction openings. The following general rules should be observed:

(*a*) Enclose the process as much as possible. The total rate of air flow into an enclosed or semienclosed hood is determined by two factors: (1) The air velocity through the openings in the enclosure must be great enough to prevent the escape of contaminated air at these points; (2) the velocity within the enclosure must be high enough to prevent the settlement of undesirable material—in certain cases no settling is permitted, in others, the velocity must not be high enough to carry away valuable product.[4]

(*b*) An exhaust hood which does not enclose the process should be placed with the opening as close as possible to the point of generation of the contaminating material, since the air velocity in the zone of hood influence varies approximately inversely with the square of the distance from the hood opening.

[4] In the design of an enclosing hood, particular attention must be paid to securing tight joints around shafting, sliding, or other moving parts of the process which must extend through the enclosing wall of the hood.

(*c*) Shape the hood and provide flanges and other guiding vanes to create maximum air flow from the area of contamination and the least possible flow from the ineffective areas in which no polluting substance is dispersed; e.g., back of the face of the hood. If the area of production is long and narrow, use a hood of the same shape.

(*d*) Locate the hood opening, or part of it, so as to utilize the directional tendency in the motion of the contaminating air for its own capture.

There is a tendency for all suction openings, regardless of shape or size, to draw air equally from all directions. This tendency increases with the distance from the hood, so that beyond a certain distance the distribution of flow becomes practically the same for all hoods. Thus, the velocity 30 in. in front of a square hood is the same for a given rate of air flow when the hood has an area of 20 sq ft as when its area is only 1 sq ft. Because of this basic tendency, the distribution of air flow toward a suction opening cannot be materially altered by changing the shape of the opening but much can be accomplished by the addition of baffles and enclosures. In this respect, a discharge nozzle is superior to an exhaust hood, since a given air velocity within a fixed area at a certain distance from the opening can be established with very much less total air flow and power consumption by *blowing* than by *exhausting*. This fact can sometimes be utilized effectively in hood design, although the use of a positive air stream is objectionable for two reasons: (1) When a positive stream of air strikes a barrier, it immediately scatters and carries dust or other contaminants with it; when the flow toward an exhaust opening is interrupted by such a barrier, on the other hand, the flow simply ceases; (2) eddies are set up at the boundary between a positive air stream and the surrounding atmosphere, thus causing the escape of some contaminated air.

REQUIRED AIR VELOCITY

The air velocity which must be developed in the zone of hood influence is determined by the velocity of air movement to be overcome, the magnitude and direction of which depend upon many factors not subject to exact evaluation. The designer should be aided in making his estimate by the experience obtained with previous installations, but at the present time almost no data pertaining to required air velocities are available.

Certain theoretical considerations are of some assistance:

(1) The velocity of *diffusion* of vapors and gases does not exceed 1 fpm; natural air movement in the room is generally higher, 25 to 50 fpm. It is reasonable to put the *minimum* air velocity to counteract natural convection currents at 60 to 100 fpm.

(2) Vertical convection currents created over hot surfaces or by the escape of a lighter gas into air vary in velocity with the square root of the difference in the densities of the column of rising gas and a parallel column of surrounding air, thus

$$V = K\sqrt{H\left(\frac{\Sigma d_2}{H} - \frac{\Sigma d_1}{H}\right)}$$

where V = vertical velocity at any point in the rising column, ft per min

$\frac{\Sigma d_1}{H}$ = average density, lb per cu ft, of the air at various points in the rising column above the level at which the velocity is measured and below the level where $d_1 = d_2$

$\frac{\Sigma d_2}{H}$ = average density, lb per cu ft, in parallel column of room air

H = height of column in feet up to level where $d_1 = d_2$
K = a constant

(3) It can be shown that large solid and liquid particles thrown off by dynamic projection cannot be captured by an opposed air current because the velocity required is so high as to be impracticable.

From the practical standpoint, the velocity required in most cases lies between one hundred and several hundred feet a minute. In the Wisconsin code

... the velocity of air motion in the plane area within the outer rim or edges of the hood and at all points of the source of contamination, except as otherwise herein specified, will be not less than the following:
For gases, 60 fpm.
For vapors, fumes, and dusts, as follows:
(a) Where the outlet consists of an enlargement of the exhaust duct arranged to house only or in part, the source of contamination, 170 times the specific gravity of entrained materials in feet per minute, except that in no case shall the velocity be less than 500 fpm ...
(b) Where the outlet consists of an enlargement of the exhaust duct arranged to house the operator as well as the source of contamination, 120 fpm.

While these figures leave much to be desired, they represent a marked improvement over the common static suction index.

Undoubtedly, the best way to determine the air velocity required to capture the contaminating material produced by a particular process is by direct experiment. Two methods are available: (1) Isolate the process from other sources of contamination, install an experimental hood, and vary the air flow until satisfactory atmospheric conditions are obtained, as determined by quantitative air analysis; (2) determine by visual inspection or another simple means, the minimum velocity necessary to turn the contaminated air into a small portable testing hood by noting the distance from the hood to the point of generation of the material to be captured when this occurs. Knowing the flow characteristics of the testing hood, and the total rate of air flow into it, one can quickly calculate the air velocity at the point in question.

REQUIRED RATE OF AIR FLOW INTO THE HOOD

The required rate of air flow Q is determined by (1) the required air velocity at the source of contamination, and (2) the location and design of the hood with respect to this source.

(1) Within a semienclosure

$$Q = VA$$

where Q = air flow, cu ft per min
V = velocity, ft per min
A = area of the hood face, sq ft

(2) Outside an unobstructed hood

$$Q = 10\ V(X^2 + 0.1\ A)$$

where Q, V, and A are as in (1)
X = distance from face of hood to source of contamination, ft.

Where the hood lies on a flat surface, the value of Q to produce a given value of V is reduced 25 per cent from the calculated value. An equal reduction is permitted when a flange is added to the face of the hood.

(3) The air flow into a hood over a tank or table is given by Dallavalle's equation

$$Q = 1.4\ PDV$$

where P = perimeter of the hood, ft
D = distance from the edge of hood to the edge of the surface over which it is suspended, ft
V = required velocity through the open area below the hood, ft per min

STATIC SUCTION AS AN INDEX OF HOOD OPERATION

Static suction is commonly employed as an index of hood operation since it determines, in part, the rate of air flow through the hood. But more important determining factors are the area at the throat (where the static suction is measured) and the restriction coefficient, thus

$$Q = 4000 A_t f \sqrt{h}$$

where Q = air flow, cu ft per min
A_t = area, sq ft
f = a factor
h = head, in. of water

The throat area is specified in many codes and an average value of $f = 0.7$ assumed, in which case the value of Q is rigidly defined. It would be better, therefore, to specify Q and permit the designer to create this rate of flow with whatever combination of A_t, f, and h is most desirable. The static suction values which have been determined by past experience to give satisfactory results are thus readily converted into values of Q, the rate of air flow.

EXHAUST PIPING

The purpose of exhaust piping is threefold: (1) To connect exhaust hoods to a central source of suction and air-cleaning plant; (2) to create the proper distribution of flow from the various hoods; (3) to insure adequate air velocity for the pneumatic transport of the collected material.

TRANSPORTING VELOCITY

(1) Vapors and gases may be moved at any convenient velocity, such as is used in general ventilation. In certain cases a drop in temperature causes condensation from the vaporous to the liquid state. Provision must be made for drainage or for maintaining the temperature.

(2) Dusts require higher velocity for lifting than for horizontal conveying, thus

$$\text{Vertical: } V = 1200 \sqrt{d \frac{\sigma}{\rho}} \quad \text{or} \quad V = 13{,}300 \frac{\sigma}{\sigma + 1} d^{0.57}$$

$$\text{Horizontal: } V = 6000 \frac{\sigma}{\sigma + 1} d^{0.4}$$

where V = air velocity, ft per min
σ = specific gravity of the material
ρ = air density
d = diameter of the largest particle to be moved, in.

(3) A chip trap removes large particles close to the hood and serves to reduce the required air velocity. Objections to chip traps are the pressure-loss introduced, the fact that all the dust is not brought to a central point of collection, and the traps require frequent dumping.

METHOD OF PROPORTIONING PIPE SIZES

Two basic factors are: (1) Area at any section should not exceed Q/V, where Q is the rate of air flow in cu ft per min past the section, and V is the minimum transporting velocity in ft per min; (2) the pressure loss produced in any branch line should equal that created in that part of the system which lies upstream of the branch when the proper rate of air flow exists in each. The rate of air flow into any hood should not depart from the estimated value by more than ±25 per cent.

The calculation of pressure losses involves no unusual steps and employs standard formulas and charts. Actual measurement of the resistance is often desirable in the case of special fittings.

It is sometimes not practicable to select pipe sizes exact enough to insure the requirements of both (1) and (2). In such cases, determine the size required under (1) and provide suitable variable resistances which are adjusted until the required distribution of flow is obtained.

ALLOWANCE FOR FUTURE EXPANSION

No additions to an existing system should be permitted which throw the distribution of flow out of balance by more than the ±25 per cent variation allowed in pipe design. Failure to observe this important requirement has resulted in overloading many efficient exhaust systems. New pipe connections are best made at a point in the main pipe downstream of all branch connections and as near the air-cleaning plant as possible. In certain cases, notably when expansion is contemplated soon, it may be desirable to design the piping and fan for the ultimate system, only the needed part of which is built, and to provide orifices in the ends of blanked-off pipe lines of sufficient capacity to admit as much air as will be handled by the future additions, thus maintaining the required velocity of transportation.

PLANT LAYOUT

Processes to be connected to one system should be located close together and with as much symmetry as possible about a center. The purpose of this is to permit the use of the shortest length of pipe and minimum number of bends, and to simplify the adjustment of pipe sizes for the proper proportioning of air flow from the various hoods.

The plant layout should be arranged to permit the locating of exhaust piping so as (1) not to interfere with the operation of cranes, elevators, and trucks; (2) to allow ready access to the piping for inspection, cleaning, and repairs; and (3) to provide maximum protection of the piping from external damage.

AIR-CLEANING EQUIPMENT

Air cleaning is required for several reasons: (1) To prevent the creation of a nuisance or hazard in the area around the outlet; (2) to prevent the recontamination of plant air from the outside; and (3) to permit recirculation of the air which is discharged from the exhaust system in the plant; this is necessary in deep mines and is also often desirable in factories to conserve heat.

Air-cleaning requirements vary with local conditions, from the most rigid in the case of complete recirculation, to a minimum for an isolated plant from which the exhaust air can be discharged without danger of recontamination.

Operating characteristics of air-cleaning equipment shall be such as to give steady and continuous operation during a practical working period and thus not to require cleaning until the end of the work shift. There shall be no serious change in efficiency with use. Means must be provided for the disposal of collected material without exposing the workmen to a hazard.

The concentration of polluting material in the discharge air should be measured by a standard technic and should not exceed a previously established level.

DISCHARGE STACK

The simplest means of disposal is through a high stack. Dilution and favorable wind currents serve to reduce the concentration to a safe level. The nature and concentration of the escaping material and local meteorological conditions, such as down-draft winds and eddies around buildings, must be carefully considered, since these determine the practicability of this method of disposal. Dust particles large enough to settle out at once must be removed before reaching the stack, if a nuisance in the immediate neighborhood is to be avoided.

PRIMARY DUST SEPARATORS

Gravitational settlement chambers, cyclones, and simple inertial chambers serve to remove relatively large particles of dust, but cannot be depended upon to take out the minute particles of hygienic interest. They may be employed for two purposes: (1) To prevent the development of a nuisance from settling dust in the discharge area; (2) to relieve the load on dust filters in a two-stage cleaning plant.

DUST FILTERS

Properly designed cloth dust filters, when not overloaded, are capable of reducing the dust concentration in the filtered air to a level well within the safe limits of dustiness. Important factors contributing to unsatisfactory filter operations are overloading, improper cleaning, and lack of maintenance.

Manufacturers of equipment must know the nature and particle size of the dust to be handled and the load of dust per cubic foot of air, as well as the rate of air flow.

COLLECTION OF GASES AND VAPORS

Gases and vapors are separated from air by physical adsorption and chemical combination and the proper method of treatment must be determined for every gas to be collected.

SOURCE OF SUCTION

Fan and motor capacity are determined by (1) total rate of air flow Q, and (2) overall resistance of the system. The total rate of air flow Q equals the sum of the rates for the various hoods. Ten per cent may be added for leakage, although this should be unnecessary with well-constructed piping. The total pressure loss equals the sum of the losses due to (1) entrance into the hoods; (2) friction in most resistant branch; (3) friction in main exhaust pipe, including bends; and (4) air-cleaning plant, including losses at entrance and discharge as well as within the plant. In order to get the static suction at the entrance to the fan it is necessary to add the velocity head in the pipe line to this sum. In general no special care is taken to convert velocity head into static pressure at transition sections, and it is best, therefore, to add for this purpose the head corresponding to the maximum velocity in the system. This usually occurs at the hood throat and is included in the static-suction reading at this point. Further addition of the resistance on the discharge side of the fan is necessary to give the combined suction and pressure against which the fan must operate. This value may or may not be equivalent to the static-pressure value employed in fan-capacity tables, depending upon how these are made up.

Adequate provision must be made for the entrance of air into the building to replace that which is removed by the exhaust system. Inlets should be arranged and located so that the workers are not subjected to harmful drafts. Fans handling inflammable vapors and explosive dusts must conform to regulations such as those which are incorporated in A.S.A. Code Z-33-1935.

Fans on systems handling abrasive dusts should be located on the clean-air side of the dust filter to avoid wear. Fans handling corrosive materials must be constructed of suitable resistant material.

CONSTRUCTION AND MAINTENANCE

Details of construction are dictated in part by local conditions, such as exposure to corrosive substances, abrasive dusts, and weather. Methods of construction should be governed to a greater extent by the question of subsequent maintenance than by initial cost. As an engineering structure, an exhaust system should command as much care in its operation and maintenance as any other part of the plant equipment. The use of light construction and improper protection of the system are not conducive to this end. Modern methods of welding make possible the economical use of welded pipe and fittings in many places instead of lighter sheet-metal construction.

Whenever possible, the manufacturer of plant machinery should incorporate the exhaust hoods in the design of the machines. Consideration of the problem of exhaust ventilation before the machine is built will result, in most cases, in a more satisfactory solution than is given by the compromise that must be adopted when the hood is added to the finished machine.

OPERATION AND MAINTENANCE OF EXHAUST SYSTEMS

Responsibility for the operation and maintenance of an exhaust system should be placed in the hands of one man. His duties should include: (1) Routine inspection and the repair or replacement of worn or damaged parts; (2) proper maintenance of the fan and motor and other moving parts; (3) operation of the air-cleaning equipment in accordance with the instructions of the designing engineer and the manufacturer of the equipment; and (4) instruction to the workers in the proper use of the system for their maximum safety and comfort.

MEASUREMENT OF AIR FLOW

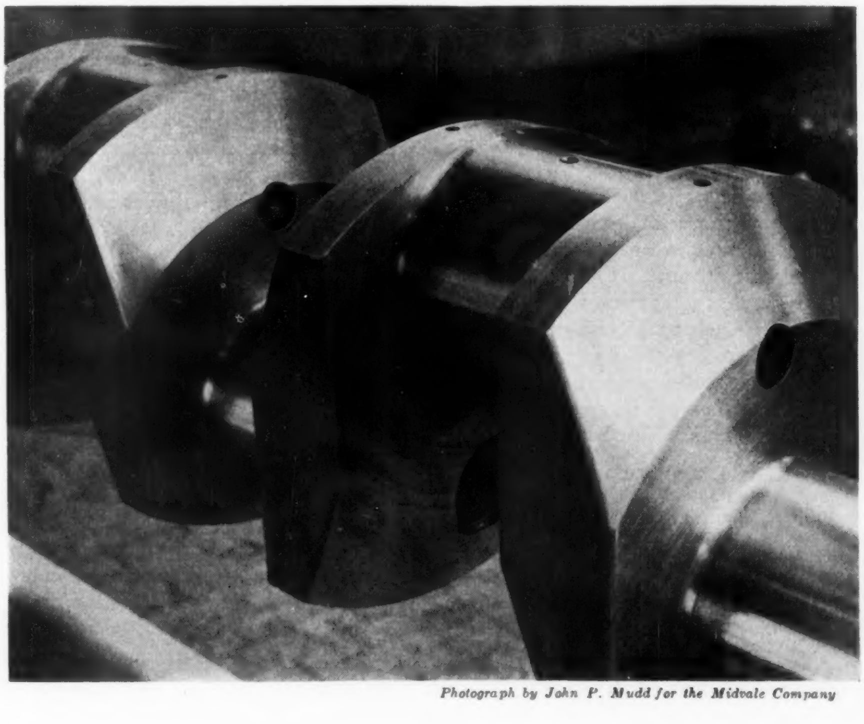
Development of the rates of air flow through the various exhaust hoods equal to the estimated requirements employed in the original design carries no guarantee that the proper degree of control will result, since these rates are only estimates. Routine measurement of air flow, however, does show whether the system is operating in accordance with the original design and is therefore a valuable index of operation. The determination of static suction at the various hoods is helpful in this respect, but in addition it is desirable to provide an air-flow meter in the main pipe to indicate the total flow. A pitot static tube may be used for this purpose. Its advantages are that it is simple to install and operate, and it introduces no pressure loss in the system. In a dust-control system it is troublesome because the pressure holes plug with dust. A venturi section in the main pipe provides a permanent meter without great cost and does not introduce an excessive pressure loss when properly designed.

TESTING EXHAUST SYSTEMS FOR EFFICIENCY OF OPERATION

The measurement of the concentration of contaminating material in the plant atmosphere and in the discharge area of the exhaust system constitutes the basic means of determining the effectiveness of the control secured. Suitable methods of sampling and measurement must be employed and the results compared with certain pre-established standards of permissible concentration. Methods of analysis and allowable concentrations have become sufficiently well-standardized to warrant their inclusion in the specifications for exhaust systems for many industrial processes.

A few tests at the outset of plant operation cannot be relied upon, however, to give a true measure of control over a long period of time. It is essential to make certain that the design of the system is fundamentally sound, that the system is operated in accordance with the instructions of the designing engineer and the manufacturer of the equipment, and, finally, that the system be properly maintained.

In certain cases, conditions may warrant the installation of automatic recorders of concentration of the polluting material. Such instruments are available for certain kinds of dusts and for various gases. In other cases, routine measurement of concentration through the use of simple measuring instruments is to be recommended. Suitable measuring instruments are available for many industrial contaminants.



Photograph by John P. Mudd for the Midvale Company

PLANNING—THREE VIEWPOINTS

By B. ALDEN THRESHER

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DISCUSSION about the possibility and desirability of a planned society commonly proceeds on one of three different planes or levels: First, the engineering or physical level; second, the economic or value level; and third, the political or, more broadly, the social level. Three books selected from the large current literature of the subject illustrate these three planes: Loeb's "Chart of Plenty,"[1] Mrs. Wootton's "Plan or No Plan,"[2] and Lippmann's "Method of Freedom."[3] This arrangement of titles corresponds roughly to the respective levels of analysis just mentioned, to an ascending order of complexity in the problems dealt with, to a descending order of naiveté in the manner of treatment, and to an ascending order of conservatism in estimating the potentialities of planning.

"NATIONAL SURVEY OF POTENTIAL PRODUCT CAPACITY"

On the physical level, the questions to be answered are: How much can we produce? and, How much should we consume? To answer these questions, Mr. Loeb and his associates in the "National Survey of Potential Product Capacity" have made an elaborate statistical survey of productive capacity, compared with actual 1929 output and with an estimate of consumption needs. The information has been ingeniously summarized into a "flow sheet" which takes some account of the complexities of production by stages, with finished goods coming forward into use at points whose remoteness from the extractive industries varies widely.

To focus the argument, let us assume that the statistical estimates are correct. They indicate, briefly, a potential capacity, with existing plant and manpower, to turn out a national dividend valued at 135 billion dollars, or $4400 per family, an increase of about 40 per cent over the 1929 figure. Thus far the author is on firm ground. The physical capacity is there. Nor can we disagree with the conclusion that our existing system results in much restriction of output in the interest of maintaining monopoly price. The solution offered, however, is the uncritical one of distributing "purchasing power," together with "central control" of the production of "non-scarce" goods.

It is, of course, clear that the defect in our economy is not primarily technical, but concerns those intangibles of mutual balance, organization, and incentive which are essential to the smooth operation of the economic process. It is not to be expected that distribution of purchasing power will serve to redress this balance. To the extent that it does not, the effect will be simply an uneven rise in prices. The author fails to realize, moreover, that *scarcity* is entirely a relative term, and that the problems of *central control* may well exceed in complexity those which now confront us. These two terms, in fact, are keys to the economic aspects of the problem, to which Mr. Loeb, in his preoccupation with the physical aspects, gives scant attention. The economic aspects, however, form the main theme of Mrs. Wootton's analysis, to which we now turn.

"PLAN OR NO PLAN"

"Plan or No Plan" is an able comparative study of the unplanned capitalist economy and the Soviet planned economy. The strength and weakness of each is appraised, and the methods by which each can meet the problems of balance and adjustment are subjected to economic analysis. Mrs. Wootton, so to speak, begins where Mr. Loeb leaves off, and grapples with the tough issues which he so airily glosses over, such as the nature of scarcity, the problem of balance, and the technique of central control. Mr. Loeb sees the production problem in terms of "bottlenecks" of physical capacity. Get rid of these, or make adequate allowance for them, and all will be well. Mrs. Wootton, however, is more realistic as well as more subtle.

She apprehends the opposing pull of comparative costs and sees the economic process as one of continual, mutual adjustment of these costs to each other and to the utility of one more or one less unit of product. The cost of producing bread depends not only on how much bread is or "ought" to be produced, but on how many shoes or tacks or false teeth are produced. Mr. Loeb, with his bottlenecks, is on safe ground as long as he hews to the line of a given pattern of consumption and a scheme of production defined in advance. But this is only the beginning of the problem of economic control, i.e., to obtain continuous mutual adjustment of the system to internal changes. The old dilemma of value remains: How much of one thing is equivalent to a unit of something else? How can we equate one man's pleasure with another man's toil; the satisfaction of the consumer to the effort of the worker? The price system provides machinery for this comparison, albeit defective machinery. The controlled system substitutes an authoritative judgment which must make its own assumptions about what people want or what is good for them.

Mrs. Wootton works over the ground of this analysis with care and no little skill. She checks her conclusions against actual results under both systems. When, in consequence, she finds some balance of evidence in favor of planning (not, of course, the same thing as communism), we feel that she has at least passed beyond wishful, and into analytical, thinking. The "dollar vote" mechanism performs the service of equating work and pleasure, costs and prices, subject to two leading defects. First, the machinery of competitive markets is imperfect, so that, for example, a low money wage may throw on relatives or on the state the burden of later supporting a broken-down worker. Price does not include all "real" costs. Second, because incomes are unequal, a large money bid for a product or service does not necessarily reflect a higher real "want" or "need" on the part of the bidder. Out of these two type situations, plus the periodical breakdowns of depression, one can develop the entire case against individualism.

The case against control may be exemplified also by two type situations. The first is the well-known fact that the first Five

[1] "The Chart of Plenty," by Harold Loeb and associates, Viking Press, New York, N. Y., 1935, 180 pp., $2.50.

[2] "Plan or No Plan," by Barbara Wootton, Farrar & Rinehart, Inc., New York, N. Y., 1935, 360 pp., $1.60.

[3] "The Method of Freedom," by Walter Lippmann, The Macmillan, Co., New York, N. Y., 1934, 117 pp., $1.50.

Eleventh of a series of reviews of current economic publications affecting engineering, prepared by members of the Department of Economics and Social Science, Massachusetts Institute of Technology, at the request and under the sponsorship of the Management Division of The American Society of Mechanical Engineers.

Year Plan pushed heavy industry for future use at a pace which half starved the consumer-goods industries. Under the control of a "market" rate of interest, a different and more humane balance would have been struck between "some goods now and more goods later." For our second case, consider a certain Soviet orphans' home in which the children, on half-time work, turned out simple electrical fittings. The director explained with pride that the home was completely self-supporting. It developed, however, that a monopoly existed and a high price was charged to make this possible. Buyers of these fittings were, in effect, assessed the cost of running the children's home. Here, then, is a converse case of unbalance. Where the competitive economy may exclude certain costs from the market price, the controlled economy may load the price irrationally with costs which should logically be borne in a different manner.

If we translate these cases into other terms and multiply them, we get a picture in which neither *plan* nor *no plan* gives more than the roughest possible adjustment of production to wants. But, as our author points out: "If the planners make mistakes exactly like the mistakes of capitalist producers, and embark on lines of production which are expected to be profitable but find a disappointing market, they are by no means obliged to shut up shop unless they wish. A mistake is, of course, still a mistake, but there is no necessity for it to reveal itself in the particular form of unemployment and unused plant. Instead, goods can be offered below cost to a public which does not consider them worth the money spent in making them, and the mistake is paid for in that way." Hence there may be a less direct connection between mistaken estimates and unemployment in such a system than in ours. The planned economy, like the doctor, can bury its mistakes, or at least absorb them in ways which make them less obvious. Or, to change the metaphor, its mistakes, instead of breaking out in local boils on the body politic, can be reabsorbed and the virulence of the poison distributed more widely and imperceptibly.

The foregoing remarks are too compressed to do justice to Mrs. Wootton's book. It is an analysis primarily on the economic plane, and colored perhaps by the viewpoint of an English writer thinking in terms of a compact and homogeneous country. The terrific social and political upheavals that have accompanied the institution of planning in Russia, right down through the famine of 1933 and the collectivization of the peasants, are passed over lightly. It is the virtue of Mr. Lippmann's little book that it takes account of the political accompaniments of such methods of assuring physical productivity and of compelling economic balance. Mr. Loeb and his engineers hail with visionary rapture the planned state; Mrs. Wootton admits it grudgingly. Mr. Lippmann rejects it, except in a mild and tentative form.

"THE METHOD OF FREEDOM"

The analysis in "The Method of Freedom" is more sophisticated and wiser than these others, because by implication it includes their arguments, and then goes beyond them. As Lippmann points out, the real choice is not laissez-faire versus collectivism, but solely *what kind* of collectivism. And here the main contrast is between the sort of directed economy which the previous authors come to, i.e., one subject to thoroughgoing central control, and, on the other hand, what Lippmann calls a compensated economy, or the method of free collectivism. "The military pattern is the basic pattern of any directed social order. . . . In an economy which is directed according to a plan and for definite national objectives, the official must be superior to the citizen, and the hierarchy of officials who compose the government must be absolute as against the individual. . . . The law is the will of the rulers above him. They are subject to no law. There are no customs, contracts, constitutions, or ancient usages which limit them. His rulers are controlled only by their own judgment and by the scope of their own power."

The method of free collectivism, *per contra*, arises naturally out of the long series of government measures which have grown up to regulate and control capitalist industry in many countries. While it is acknowledged that the state has an obligation to protect the standard of life and insure the smooth running of the economy as a whole, there is, nevertheless, freedom of individual initiative within wide limits. But in the compensated economy of Mr. Lippman, the state must go beyond the mere prevention of abuses. It must throw its weight now this way, now that, like live ballast in a sail boat, to compensate for the cumulative errors which mass emotion, mass buying, and mass investment bring about. Such a system is not an abstract theory, but is built out of elements already in practical use.

Such compensatory devices are, for example, the control of credit and currency by central banks; the long-range planning of public works; discriminatory taxation, repressing here, encouraging there; control of the capital market in ways illustrated, for example, by our recent securities legislation. All these devices are natural outgrowths of institutions to which we are already attuned, and which accord with the genius of our people. On the other hand, it has never been demonstrated that a system of thoroughgoing control can coexist with political freedom. Existing examples point to the reverse.

Addressing himself to the practical problems of operating such compensating devices in a representative democracy, Mr. Lippmann turns up the important principle that the people who are applying the compensatory forces must usually be working directly against immediate popular opinion and against pressure groups representing special interests. The inability of the modern democratic state to administer policies that require independence, foresight, and devotion to general, not local, interests, he traces to the fact that legislatures have acquired the initiative in fiscal matters. Historically and rightly, he argues, the power of the purse has meant the power of the assembly to refuse revenues, and grant them "on terms." But in modern states, the legislature, instead of telling the executive what he *may* spend, tells him what he *must* spend; not merely *how much* he must tax, but *what* he must tax. An indispensable condition of free collectivism, then, is an executive initiative in fiscal matters, with the legislative branch serving only as a check and balance.

Such a free collectivism "as indicated in the policies of the English-speaking countries during the present crisis is the method of liberty in the twentieth century as laissez-faire was its method in the nineteenth." Its special concern is to bring as many as possible into the "middle condition" which Aristotle saw as the great source of stability in the state. "Free men with vested rights in their own living: Men like these alone, and not employees of the state or the disinherited who today walk the streets and are at home nowhere, can constitute a free society."

The foregoing brief and sketchy characterization of these three books does real justice to none of them. This the reader can remedy by perusing them for himself. The aim of the reviewer has been rather to characterize each and to place it in a larger setting. Study of the three books, in the order named, will go far toward providing the elements of a humane and liberal education in this much-abused aspect of political economy.

ENGINEERING PROGRESS

AERONAUTICAL ENGINEERING

Automobile Engines for Aircraft

THE author believes that the activities of the Bureau of Air Commerce in the direction of conversion of automobile engines for aircraft use is unfortunate. He considers the matter primarily from the point of view of weight and shows how much heavier automobile engines are than aircraft engines. Moreover, an automobile engine is mostly driven at half throttle or less, while an aircraft engine operates some 75 per cent to full throttle most of the time. Parts of automobile engines used for aircraft are widely accessible, but skilled aircraft repair mechanics are not. The author expresses a doubt whether an automobile engine compares favorably with the modern aircraft engine in respect to dependability. The cost of the former is lower, which is largely due to mass production, and the author doubts whether an engine designed specifically for light aircraft can be manufactured and sold at prices comparable to automobile engines. The article is highly controversial and cannot be abstracted in full. A suggestion is made that an engine be developed which is basically suitable for rear-end mounting on automobiles as well as for aircraft, the matter of weight being a serious consideration in both classes. (Glenn D. Angle in *Aero Digest*, vol. 27, no. 4, October, 1935, pp. 23 and 102)

APPLIED MECHANICS

Surge in Springs

THE author discusses the surge condition generally and points out the possibilities of trouble from resonance. To study this phenomenon special apparatus was set up in the laboratory of the Department of Mechanical Engineering of the Pennsylvania State College, described in detail in the original article. These investigations have shown that surge is an important factor in the behavior of springs in many applications, even in those of relatively low speed.

By test it is possible to determine the speed of the cam and the initial tension which will reduce the effect of surge in any given spring to a minimum. Available formulas for determining the natural period of such springs do not give results sufficiently close to the actual to be of much use.

The author recommends the Simmons formula to be used as it approximates the results of Love, but points out that the theoretical formulas unfavorably give results from 10 to 15 per cent higher than those shown in the actual spring. (C. H. Kent, Professor of Mechanical Engineering, Pennsylvania State College, in *Machine Design*, vol. 7, no. 10, October, 1935, pp. 37–39)

CORROSION

The Duraspray Rust-Proofing Process

THIS process consists primarily in applying first a priming coat of red-lead paint, then dry-spraying on to the wet surface of this coat a finely divided metallic powder consisting of specially prepared zinc dust containing a certain proportion of aluminum, and finally applying a finishing coat of paint of a character and color to suit the particular job. The priming coat is of special undisclosed character. The metallic-powder spraying equipment is coupled by means of flexible hose to an air compressor delivering 21 cu ft of air per min at 40 lb per sq in. pressure. (*Engineering*, vol. 140, no. 3641, Oct. 25, 1935, p. 456)

ELECTRICAL ENGINEERING

High-Frequency Current for High-Speed Motors

THE use of high-frequency current is attributed to the desire to obtain higher speeds than those obtainable with current of normal frequency. With 60 cycles, for example, maximum motor speed obtainable is that of a two-pole unit, or 3600 rpm. High-frequency motors are generally employed when it is desired to avoid the necessity of intermediate transmission such as gear, belt, or chain drive. One of the largest fields of application is in woodworking.

Two methods are available for raising the frequency above that of the supply line; by motor generator and by frequency converter. A motor generator employed for frequency changing requires a generator having a sufficient number of poles to produce the desired frequency when running at the speed of the driving motor. The frequency converter consists of a motor-driven induction generator similar to a wound-rotor motor. Motor-generator sets are less commonly used than frequency converters because of the latter's higher cost and necessity of attendance, but frequency converters have the advantage that the high-frequency output is independent of the voltage fluctuations in the supply lines. Further details about this kind of apparatus, including combined autotransformer and frequency converter, will be found in the original article. (Geo. H. Hall, Cons. Engr., in *Electrical World*, vol. 105, no. 21, Oct. 12, 1935, pp. 34–35, and 90–91, illustrated)

ENGINEERING MATERIALS

Plaskon

PLASKON was originally developed at the Mellon Institute of Industrial Research at the University of Pittsburgh on behalf of the Toledo Scale Co. and is now being made at the Toledo Synthetic Products, Inc., at Toledo, Ohio. It is of the group of urea compounds. It is a heat-hardening plastic for hot-welding, compounded from nitrogenous resins, fillers, pigments, mold lubricants, and softening agents. The original article states in some detail the method of making parts from this material and the precautions in molding. The moldings can be used as they come from the mold or after a light buffing. They can be tap-controlled or otherwise machined. Plaskon moldings can be joined to one another by being cemented, by pressure fits, and by rivets or screws. The control of molding conditions, the making of molds, and the molding of a large casing are described in the original article.

The physical properties of plaskon may be briefly noted as follows: Specific gravity, about 1.5; flexural strength (modulus of rupture), 10,000 to 20,000 lb per sq in.; compressive strength, 25,000 to 35,000 lb per sq in.; tensile

strength, 8000 to 13,000 lb per sq in.; hardness on the mineral scale, 3 to 3.5; hardness on the scleroscope scale, 80 to 95.

The list of applications where Plaskon can be employed usefully and for which it is not recommended are given in the original article. (*Machinery*, New York, vol. 42, no. 3, November, 1935, pp. 169–174, illustrated)

Subcutaneous Effects During the Scaling of Steel

THE author deals with minor changes of structure or composition of articles during heat-treatment, which may affect the surface finish. He deals primarily with changes which have been observed during the oxidation of various steels in the laboratory. Some of these, however, may prove to be of industrial interest.

The experiments made by him show that when steels containing certain elements in contact with the scale are heated, globules and spots are formed within the steel. It was established that the presence of oxygen is necessary for the formation of these globules and spots, and this oxygen is supplied by the scale in the cavity and obtained during the initial stages from such oxides as Fe_2O_3 and Fe_3O_4, and during subsequent changes from FeO which would cause the main effect. The character of the globules and spots differs according to the elements contained in the steel.

Whenever scaling of an article occurs—for instance, during heat-treatment—particularly if the surface oxidation is slow, some formation of globules and spots is to be expected. Whether the affected area is removed by subsequent processes, such as pickling or machining, will depend, inter alia, on the extent of the affected area and the amount of metal removed. It would also appear that the more oxidizable elements contained in the steel, the greater is the extent of precipitation and formation of globules and spots, so that where a specially good surface is required the steel should contain a minimum of elements having a high affinity for oxygen—that is, any excess of deoxidizing agents, such as aluminum, should be at a minimum.

Unless the affected area is removed completely, the effects of the phenomenon on a steel intended to be fatigue-resisting may be to initiate surface cracks. In tin-plate manufacture, while the affected area, if any, must be extremely thin, owing to the rolling processes subsequent to its formation, its possible presence cannot be entirely disregarded. It is conceivable that its effect would be to increase the possibility of porosity, particularly if the sheet is to be used for deep stamping. The surface of the sheet containing the nonmetallic particles might not be able to withstand the stressing occurring in the process, and minute incipient cracks might be formed at the surface of the steel. The support of the tin coating would not then be continuous, so increasing the liability to failure and the resulting porosity of the coating. (*Engineering*, vol. 160, no. 3638, Oct. 4, 1935, pp. 378–379, illustrated)

Beryllium

DETAILS of the manufacture of beryllium and a brief statement of the properties of the metal itself are contained in this article, and there is a table of the physical properties and technical characteristics of beryllium copper with 2.5 per cent beryllium, beryllium copper with 1.9 per cent Be, and beryllium contracid with 0.75 per cent beryllium. It is stated that the price of raw beryllium in Hamburg is £1 for each per cent of BeO per ton. It is said, however, that the present price is much lower than the one which prevailed only a few years ago.

The consumption of beryllium in Germany at present is between 500 and 1000 kg per year. Much greater amounts are consumed in the United States, particularly in the manufacture of beryllium bronze. (W. Hessenbruch in *Metall und Erz*, vol. 32, no. 11, June, 1935, pp. 234–237)

FUELS AND FIRING

Motor Spirit From Tar

THE Department of Scientific and Industrial Research in England published two reports (Technical Papers Nos. 40 and 41) dealing with the conversion of tars into motor spirit by means of hydrogenation cracking. According to these reports a wide variety of catalysts was tried. The general conclusion is that a mixture of commercial molybdic acid and sulphur was the most effective substance. Three groups of tars were tried as raw materials: From different low-temperature carbonization processes; from five coals of different types carbonized in vertical cast-iron retorts; and from four coals carbonized at rather high temperatures in narrow, vertical, brick retorts. The tars of the third class were definitely more difficult to treat. (*The Steam Engineer*, vol. 4, no. 12, September, 1935, pp. 503–504)

INTERNAL-COMBUSTION ENGINEERING

Supercharging

A SYMPOSIUM of four papers on supercharging dealing respectively with aircraft engines, marine oil engines, touring-car engines, and supercharging generally is presented.

In discussing the application of supercharging to aircraft engines, A. H. R. Fedden states that it is true to say that it would be impossible to produce the large modern aircraft engines with their present power-weight ratio without the aid of supercharging, and the disposable load and maximum speed of aircraft would be most adversely affected by the increased weight, bulk, and drag entailed by the use of naturally aspirated engines of the same power as existing supercharged types. For instance, a single-seater fighter driven by an engine giving 700 hp at ground level might have a top speed of 200 mph at an altitude of 15,000 ft, but with an engine giving 700 hp at 15,000 ft it would show an increase in top speed to 248 mph, because the engine rated at 700 hp at ground level would give only about 420 hp at 15,000 ft.

The extent to which the supercharging can be carried out on any engine depends upon a number of factors, such as the octane number of the fuel, piston compression ratio, fuel-air mixture strength, mixture temperature, ignition advance, and the shape and size of the combustion chamber. It can be seen, therefore, that the purpose for which the engine is to be used must be taken into consideration, and while one can say generally that for the same increase in overall compression ratio, more power can be obtained by increase in supercharging pressure rather than by increase of piston compression ratio, such a division of overall compression ratio adversely affects the fuel consumption, which is an extremely important point on engines employed in long-range aircraft.

It has been clearly proved in the past that it is unwise to endeavor to increase by boosting at ground level the power of an engine having inadequate breathing organs, as such a procedure inevitably brings trouble in its train. To obtain satisfactory and efficient supercharging the engine should have the largest possible valve and port areas.

As an example of what can be done with an air-cooled aircraft engine boosted at ground level, the Bristol Company has recently completed an Air Ministry type test on the "Pegasus X" engine, which gives 920 hp at ground level for take-off, and 875 hp at 6000 ft, the net

dry weight of this engine being only 995 lb.

As regards the mechanism of supercharging, the mechanically driven centrifugal-fan type is generally preferred.

The Bristol Company has recently completed an exhaustive research for the Air Ministry on geared centrifugal blowers, which covered some fifteen months' work and included an investigation into different types, diameters, and clearances of impellers and diffusers and impeller bearings. From this research it has been possible to obtain a fair idea of the possibilities of this type of blower, and the detail improvements which may be expected. Where it is necessary to maintain considerable power for take-off and climb, it is not thought reasonable to use a single-stage blower of centrifugal type with a compression ratio of more than 1.85/1 (giving a rated altitude of 15,000 ft), owing to the power losses in the blower when running throttled on the ground and the power limitations entailed by mixture temperature with the available standard fuels.

The exhaust turbo-compressor type has so far proved difficult to arrange neatly on a radial engine, but can be better accommodated on the in-line type. In the author's opinion the exhaust turbo-compressor has been unduly condemned, and it has been shown that this type of turbine provides an efficient silencing and flame-damping system for the engine.

MARINE OIL ENGINES

In discussing supercharging in connection with marine oil engines Sterry B. Freeman says that at the present time in marine work a number of supercharged engines working on the four-stroke cycle are run at mean indicated pressures of 134 lb per sq in., which is approximately 50 per cent higher than that employed by induction or nonsupercharged engines. The heat given up to the cylinder cooling water is not increased by the additional amount of fuel burned per stroke, consequently the heat stresses in the metal are not increased; also the effect of the better scavenging and cooling supplied by the supercharged air helps to keep down the temperature of the metal. It has been general experience that the best combustion and the greatest economy of fuel have been attained when scavenging has been most complete, and this is not the least part of the benefit of supercharging.

TOURING-CAR ENGINES

The touring-car engine situation was discussed by L. E. W. Pomeroy. Translating the "controlled" horsepower gain into terms of road performance, it is necessary to realize that the percentage of increase in surplus horsepower is far greater than that of net horsepower, "surplus" horsepower being defined as the margin available at any speed above that required to overcome wind and tractive resistance. Thus, while the net horsepower may be increased by 50 per cent at 45 mph, there will be 100 per cent gain in surplus horsepower which will rise to 150 per cent at 50 mph, and to infinity at 60 mph, taking as an example a 10-hp saloon car with this speed as its maximum.

These impressive figures are realized because supercharging is fundamentally the only way an engine can be given an increased effective capacity without enlarging the overall dimensions, or the windage of the car, and with an increase in weight of under 2 per cent. As a result, it is common for the acceleration times either on top gear or with the use of the gears to be halved, and for the top-gear speeds up main road hills to be increased from, say, 40 to 60 mph. With quite small supercharged engines, a car can be produced with a top-gear performance approaching that of a large luxury vehicle and high average road speeds can be attained in safety and without great mental or physical effort.

The development of the supercharged car has been delayed by the difficulty of producing a suitable machine having no highly loaded parts, but in order to secure good volumetric efficiency it must be manufactured with the utmost care and by reason of slight distortions of the large cam-shaped rotors, often seems to demand hand-fitting, which materially raises production costs. Another factor tending to costliness is that in order to achieve silence, a fine clearance must be maintained between the rotors themselves and between the rotors and the case.

The former clearance depends not only on the machining of the rotors, but also on that of the gears which maintain them in relative position. Production engigineers are fully cognizant of the difficulties of making gears silent, and if the rotors are regarded as two large gearwheels, it will be seen that the problem is really that of matching two sets of gears to run completely silently, a problem which, if it is not insuperable, is at least one which presents considerable difficulty.

The merits of the Roots blower are its reliability and the fact that all bearings requiring lubrication are outside the pumping chamber.

POINTS AGAINST SUPERCHARGING

A position against supercharging was taken by R. H. Ricardo, who said that it has frequently been claimed that by means of supercharging, it is possible to gain a large increase in output and in fuel economy. It is not possible to make good both claims. If the additional air is to be used for anything like a proportional increase in power, and if the maximum pressure is limited as it must be in practice, then the effect is to curtail the ratio of expansion, and therefore to lower somewhat the efficiency. If it is used to increase the air-fuel ratio, then it will provide an improvement in efficiency by increasing somewhat the ratio of expansion, but not in power output.

Nature offers an unlimited supply of air at a pressure of 15 lb per sq in.; we are not bound to take what is offered, but we must be prepared to pay extra if we decline to accept what is available. We must pay for it either by the power required to drive the blower mechanically or by accepting the inconveniences and limitations of an exhaust-driven blower.

The author apparently can see some reasons for using supercharging for increasing the power of an existing engine but not (except in certain special applications) for installing it in an engine newly designed.

Among other things he states the following: One is often told to look at the exhaust temperature of a supercharged engine and note the low reading, with its implication of high thermal efficiency. Such a reading is bound to be low, for the hot exhaust gases are diluted with cold scavenge air, but that does not mean that the efficiency is increased, or that the cycle is any cooler. One is almost tempted to suggest that scavenging is not so much an advantage for the engine as a positive necessity for the turbo-blower so that its temperature may be kept within bounds.

One is told, too, to look at the reduced heat flow from the cylinder head. By far the greater part of the heat which passes into the cylinder head is given up by the outgoing gases in the exhaust port and this is also greatly reduced by dilution with cool air. One can always cool his soup by blowing it, but that does not economize the cooking. When one looks at the piston temperatures, one finds rather a different story, and it must be remembered that the piston temperatures are the most truthful indication of the efficiency, and the piston the most susceptible part of any engine. (Symposium before the Internal-Combustion

Engine Group, Institution of Mechanical Engineers Proceedings, vol. 129, 1935, pp. 197–217)

Scavenging of Two-Stroke-Cycle Carburetor Engines

THE conventional method of scavenging small high-speed two-stroke-cycle carburetor engines is shown at the left of Fig. 1. This is said not to have proved to be entirely satisfactory, and a new method of scavenging has been developed by Schnürle shown at the right of Fig. 1.

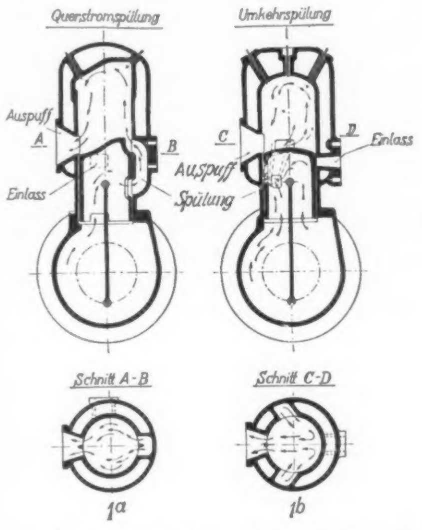


FIG. 1 DIAGRAMMATIC PRESENTATION OF THE CONVENTIONAL AND NEW METHODS OF SCAVENGING TWO - STROKE - CYCLE HIGH-SPEED CARBURETOR ENGINES

(*Querstromspülung* = crosswise scavenging; *Umkehrspülung* = reverse scavenging; *Auspuff* = exhaust; *Einlass* = admission; *Schnitt* = section.)

The characteristic feature of this new method of scavenging is the absence of a baffle projection on the top of the piston, giving the piston a clean arch top. The gases are handled by means of slots so as to produce what is claimed to be thorough scavenging of the cylinder with a minimum of gas losses. It is claimed that the combustion chamber is more efficient with the new piston. To what extent the improvement in operation is due to the shape of the piston, or to the new method of scavenging, has not yet been completely established. It is claimed, however, on the basis of tests at the Institute of Internal Combustion Engineering that there is an improvement.

It is also claimed that it has been found that any rise of temperature in the charge before the closing of the exhaust slot affects the "quantitative" scavenging efficiency in the same manner as if the scavenging medium were used to a greater extent. It is further claimed that of the improvement in efficiency about 65 per cent may be ascribed directly to the new scavenging process and 35 per cent to the higher compression ratio made possible by the shape of the piston. Any lowering of temperature in the scavenging-pump chamber not only improves the output but correspondingly raises the quantitative efficiency of scavenging. (Klaus Karde in *Automobiltechnische Zeitschrift*, vol. 38, no. 15, September 10, 1935, pp. 421–426, 8 figs.)

Wolf Airless-Injection Engine for Touring Cars

THIS engine has a piston stroke of 120.6 mm and a cylinder bore of 85 mm, giving a swept volume of 2.75 liters. Recently a number of private owners of cars of different makes have substituted it for their original engines. Trials in Russia are briefly reported here. The original article gives power and torque curves. The upper curves in each case

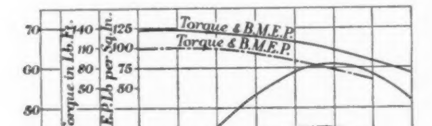


FIG. 2 POWER AND TORQUE CURVES OF A WOLF AIRLESS-INJECTION ENGINE FOR MOTOR VEHICLES

have been obtained from the engine fitted to a racing car and the lower from a commercial-vehicle engine. A description of the design of the engine will be found in *Engineering*, vol. 136, 1933, p. 583. (*Engineering*, vol. 140, no. 3640, Oct. 18, 1935, pp. 426–427, 5 figs.)

Influence of Benzol Additions to Gasoline Alcohol

THE author enumerates the advantages of benzol additions, such as increased resistance to pinking. These are well known and therefore not reported here. The tests were performed with mixtures of various proportions and with various nozzles. Only the general conclusions are stated here.

Mixtures of 5 per cent of benzol did not seem to be greatly affected by the sizes of nozzles selected. A table in the original article gives data as to engine output and fuel consumption. Where ten per cent of benzol has been tried with some nozzles, better performance at speeds above 1200 rpm was found than with straight alcohol gasoline. With some other nozzles the performance fell off at speeds above 2000 rpm. It was found generally that with certain nozzles the consumption of the mixture containing benzol fell off with increase of speed, and were generally lower than that of the gasoline-alcohol mixture. With other nozzles the consumption fell off at first but at speeds above 2800 rpm began to increase. Apparently the dimensions of the air nozzle had a deciding effect in this case.

Data are given in the original article for cases of 20 per cent benzol and a mixture of 20 per cent by volume of anhydrous alcohol, 30 per cent by volume of benzol, and 50 per cent by volume of gasoline, as well as a mixture containing 25 per cent by volume of absolute alcohol, 30 per cent by volume of benzol, and 45 per cent by volume of gasoline. The consumption in both cases was apparently less than that of straight gasoline-alcohol mixtures for about the same power output, although the second of these two mixtures did not turn out quite so well as the first. (Prof. J. Formánek, *Automobiltechnische Zeitschrift*, vol. 38, no. 16, August 23, 1935, pp. 409–413, 7 figs.)

Bituminous-Coal Tar as Fuel in High-Speed Diesel Engines

ONE of the main reasons why this investigation was undertaken is because this fuel is a native German product and if successful could be used instead of imported fuels. The matter of effect of fuel on the process of combustion generally is discussed somewhat briefly.

Tests on starting have shown that it is impossible to start even a warm engine with bituminous-coal-tar oil after only a few seconds of standing still without some auxiliary starting device. This can be done with a hot spot, however, and methods of installation are discussed in detail.

The conclusion to which the author comes is that it is necessary in order to ignite heavy fuels to maintain high temperatures in the combustion chamber of a Diesel engine, and that this must be accomplished by some means which would not have any deleterious effect on the quality of the combustion which then takes place.

A process, which, it is claimed, does this very thing, has been developed for

precombustion-chamber machines and has been tried on three motors of various constructions. In this case the air flowing through the precombustion chamber was preheated in a heat-storage device located at the point of maximum heat transfer. It is said that with this device bituminous-coal-tar oil, which is by far the most difficult to ignite of all other fuels of this class, could be burned in a satisfactory manner in high-speed precombustion-chamber engines. (Dr. of Engrg. Karl Zinner, *Zeitschrift des Vereines deutscher Ingenieure*, vol. 79, no. 44, Nov. 2, 1935, pp. 1319–1326, 15 figs.)

Diesel Dredge "Jewett"

THE *Jewett* Diesel dredge is an unusual combination of pipe-line dredge and large river towboat, the hull having some of the characteristics of each type of vessel. The result is a powerful suction dredge that is independent of towboats and is able to move to any desired location under its own power. The dredge equipment consists of a centrifugal type of pump having a 22-in. suction line driven by a Busch-Sulzer six-cylinder Diesel engine rated 1600 bhp at 250 rpm. The engine is connected with the dredge pump by means of a Farrel-Birmingham gearflex coupling. The propelling machinery comprises two 750-hp Busch-Sulzer Diesels designed to operate at 250 rpm and drive cast-steel adjustable-speed propellers having four blades.

The equipment has a number of interesting features of which only a few can be mentioned here. The first is a 450-hp motor mounted on the dredging ladder and used for operating the cutter head. This motor is connected through Farrel-Birmingham reduction gears to the cutter-head drive shaft. It is supplied with current from a 375-kw motor generator, and speed control is obtained by varying the field voltage of the generator.

A large winch is mounted on the forward end of the main deck and is used for raising and lowering the dredging ladder, and for hauling to port or starboard as required during dredging operations. The two hauling drums and the hoisting drums are operated by a single motor, independently controlled by means of brakes and clutches operated by pneumatic cylinders. These pneumatic cylinders are operated from the dredging control room on the upper deck and air for the system is supplied from a low-pressure air system. This low-pressure air system includes a motor-driven two-stage compressor which discharges to two tanks 30 in. in diameter and 5 ft long, the air being stored at 125 lb pressure. The control of the pressure in this system is entirely automatic, the compressor starting up when the pressure falls to 120 lb and stopping when the pressure reaches 130 lb. The winch motor is of 125 hp and drives the winch through a Farrel-Birmingham speed reducer. A 105-kw motor generator supplies current for this motor, and speed control is obtained by varying the generator field voltage.

A completely equipped machine shop having all the machine tools required for ordinary maintenance work is installed. The water system is unusually complete and complicated but cannot be described here. To facilitate the handling of machinery parts in the course of maintenance and operating work complete hoisting facilities are provided.

In order to make use of the heat available in the exhaust from the main dredging engine which will be in operation a large part of the time, an exhaust-gas boiler of the Clarkson type manufactured by the Electric Boat Company is to be installed. This boiler has a capacity of 815 lb of steam per hr at a pressure of 25 lb when the dredge-pump engine is operating at rated load. This boiler is arranged for burning oil fuel when no exhaust gases are available, and the oil-firing system is entirely independent of the exhaust heating system. (*Motorship*, vol. 20, no. 11, November, 1935, pp. 416–418 and 424, illustrated)

Dissociation of Combustion Gases and Its Influence on the Efficiency of Carburetor and Diesel Engines

THIS is an extensive investigation, and only the part dealing with the dissociation of gases itself will be abstracted here.

SPECIFIC HEAT OF GASES

Up to a few years ago specific heats of gases could be determined only by experiment. The possibility of computing them from spectroscopic data was recognized but not practicable. This resulted from the fact that only within the last few years, as a result of studies in the field of band spectra and the discovery of the Raman effect, has the necessary spectroscopic data become available, while the developments in atomic physics have given the theory of determination of specific heats a solid foundation.

The deviation of the theoretical values from those determined experimentally was quite substantial at times in the past. Thus, the true specific heat of oxygen at 500 C was usually 14 per cent smaller than the experimentally determined values. Of late, however, impression is gaining that the theoretical values are more likely to be correct than the experimentally determined values, particularly in view of the work of Eucken and Mücke.

The foundation of the theory of this method of determination is briefly as follows: The energy supplied to a gas being heated appears as molecular energy, particularly as kinetic energy in motion of translation, kinetic energy in motion of rotation, and the energy of atoms oscillating back and forth in the molecule. If the distribution of energy in a single molecule be known, the internal energy and hence the specific heat of the gas can be determined. The most probable distribution of energy in this case may be computed by using the laws of statistical mechanics. In such a case, however (apart from the matter of motion of translation), no arbitrary intermediary values of energy in a molecule are possible, as was assumed in the classical kinetic theory of gases, but only a certain number of predetermined stages of energy. In the case of the energy of rotation these stages lie so close to each other that, in so far as their effect on the specific heat is concerned (with the exception of what happens at very low temperatures), the same values as in the classical kinetic theory of gases are obtained. It is only in the case of hydrogen that this is true for temperatures above room temperature.

The determination of the individual stages of energy in a molecule, and particularly of the energy of oscillations, can be effected by observing the spectrum of the gas concerned, since, in accordance with the teachings in atomic physics each line of the spectrum corresponds to the transition between two different states of the molecules, which means two different stages of energy. Here the wave length of the particular spectrum line is inversely proportional to the difference in energy between the two stages of energy of a molecule. Further, since the wave length of light can be measured with great precision, the specific heat of a gas can be determined by this process with a precision unattainable when direct measurement is resorted to.

In the case of carbon dioxide the investigation of the spectrum has not yet been completed, so that the precision of measurement is still comparatively slight. The values of the specific heat of gases used in the present investigation, are given in a table in the original article. The computation was carried out by means of the Planck-Einstein formula, based, however, on a somewhat simpli-

fied scheme of the spectrum. The equations with the necessary constants will be found in the Landolt and Börnstein Physico-Chemical Tables (in German).

The author gives an equation for the computation of the entropy of a simple gas. In this equation he employs a function $F(T)$, which expresses the functional relationship between the entropy of a semiperfect gas and the temperature. He also gives an equation for the computation of the adiabatic. The theoretical values of specific heats cannot be applied to gasoline vapor, because only comparatively simple molecules containing a few atoms of the spectrum can be handled in such a manner as to obtain all the necessary constants. The specific heats for gasoline vapor, however, have been determined elsewhere and otherwise.

DISSOCIATION

In past publications dealing with dissociation of gases in the internal-combustion engine the only cases that have been considered were the breakdown of carbon dioxide into carbon monoxide and oxygen and of water vapor into hydrogen and oxygen. In addition to these two reactions within the range of temperatures existing in an engine, others have great importance. Thus, the formation of hydroxyl according to the equation

$$2H_2O + O_2 \rightleftarrows 4OH \ldots\ldots [7]$$

in combination with the equation for the dissociation of water

$$2H_2O \rightleftarrows 2H_2 + O_2 \ldots\ldots [6]$$

giving

$$2H_2O \leftrightarrows 2OH + H_2 \ldots\ldots [7a]$$

is more important than the dissociation of water vapor according to Equation [6]. To this should be added the breakdown of hydrogen and oxygen into their atoms.

$$H_2 \rightleftarrows 2H_1 \text{ or } O_2 \rightleftarrows 2O_1 \ldots [8], [9]$$

and the formation of nitrogen oxide

$$N_2 \times O_2 \rightleftarrows 2NO \ldots\ldots [10]$$

Finally, there is the water-gas reaction

$$H_2 + CO_2 \rightleftarrows H_2O + CO \ldots [11]$$

to be used in the case of gases containing hydrogen and carbon monoxide.

From this the author proceeds to the presentation of a notation by means of which the dissociation may be indicated. Among other things, the relation between the composition and temperature is indicated. He does this by introducing a constant K_v which depends only on temperature and increases when the temperature rises. Equation [14] in the original article, the value of K_v, is next derived. It contains entropy constants, though up to quite recently their values could be determined only experimentally by direct measurement of the degree of dissociation. These measurements, however, greatly lack in precision. The idea arose, therefore, of determining the absolute entropies of the individual gases by processes based on the observation of changes of specific heat of the bodies under investigation at extremely low temperatures. Thus Eucken, Karwat, and Fried have determined for a number of gases the constants of vapor pressure which have direct functional relationship with the constants of entropy. Schmidt, who has been closely studying the subject of dissociation, has computed the constants of entropy from the relation

$$s = \int_0^T dQ/T$$

The two processes are interchangeable and therefore, given the same experimental numerical values, should give the same results. It so happens, however, that in the final results no more precision may be expected from these processes than from direct measurements of dissociation, as the author explains in detail. (Dr. of Eng. H. Kühl, *Forschung auf dem Gebiete des Ingenieurwesens*, issue B, vol. 6, no. 373, July-Aug., 1935)

LUBRICATION

Automatic Lubrication

IN THE latest models of electric accounting machines of the International Business Machines Corporation the mere raising of a T-handle of a lubricator provides the impulse that oils all of the bearings simultaneously. The entire operation of lubricating the machine requires only a few seconds. A sectional view of the new lubricator is shown in Fig. 3. A small piston pump is operated by a T-handle at the top of the reservoir. A coil spring forces the piston downward to feed oil into the system.

This lubricating system, which is known as the Bijur, with the single reservoir reaches and serves 90 bearings. The schematic diagram shown in Fig. 4 in the original article gives some idea of the arrangement of the component parts of the lubricating system. In the normal position the pump piston is held down by the operating spring and the pump outlet is mechanically closed. When the T-handle is pulled the piston is raised, compressing the coil spring and drawing oil through the hollow piston and ball check valve into the pump cylinder in the space under the piston. The piston fit in the cylinder is sealed with a cup leather.

As the T-handle is released, the coil spring forces the piston downward and the upward rush of oil lifts the valve

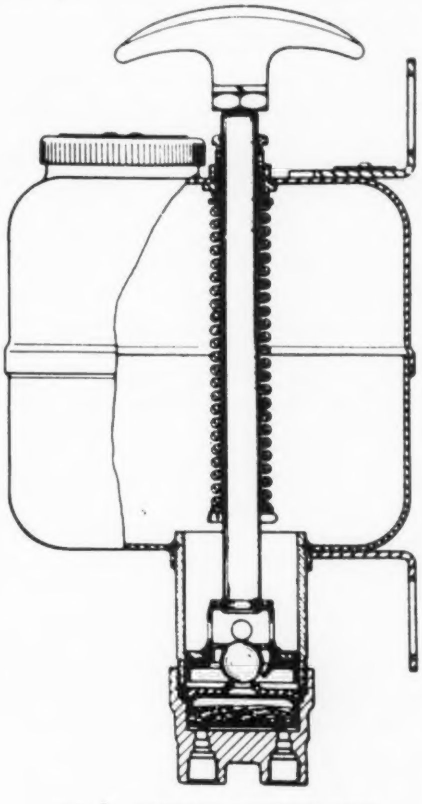


FIG. 3 SECTIONAL VIEW OF BIJUR LUBRICATOR

ball to its seat in the piston. The measured charge of oil trapped in the cylinder below the piston is then automatically forced through the felt filter into the oil feed lines by the pressure of the spring. The stroke of the piston is adjustable so that any predetermined amount of oil may be fed into the lines at each operation of the pump.

Metering fittings or "drip plugs" (Fig. 6 in the original article) form an important part of the lubricating system. Each bearing has its own drip plug and this device controls the amount of oil fed to that particular bearing. The pump, therefore, measures the total quantity of oil fed into the system and the drip plugs proportion this quantity according to the requirements of each bearing. As the amount of oil required by some bearings is greater than that required by others, drip plugs with larger flow rates are used for the larger bearings. Further information about the drip plugs will be found in the original article.

This is a closed lubricating system and the oil is fed to the bearings in the form of a heavy film. It is impossible for dirt to be fed into the bearings with the lubricant. (Fred M. Hewitt in *Machine Design*, vol. 7, no. 10, October, 1935, pp. 19–22, 7 figs.)

New Developments

IN A discussion of modern methods of refining oils, Dr. A. E. Dunstan said it was quite conceivable that if a lubricating oil were merely a lubricant it would not be refined at all, because, obviously, in the process of refining, the exceedingly valuable polar bodies, from the lubricating point of view, were necessarily removed. On the other hand, these same polar bodies were an intolerable nuisance in practice, and therefore petroleum lubricating oils had to be refined in order to separate these particularly active and objectionable substances, which conferred polarity and the property of reducing friction. Possibly, however, it was only fair to say that King's recent work on lubrication in connection with one of the committees of the Department of Scientific and Industrial Research showed that although these bodies could be removed, the lubricating oil soon produced them again, so that in the long run not much was lost.

For many years the ordinary routine practice of refining mineral oil had been based on the work of James Young, and took the form of the removal of the unsaturated polar bodies by acid and the removal of the traces of acid by absorption, but during the last year or two there had been important new developments, probably brought about by the pioneer work of the Standard Oil Company of New Jersey on the hydrogenation of mineral oils. In the course of that work it was shown that from a conventional mineral-oil stock there could be obtained a highly effective, highly refined, and extremely useful oil characterized by a very flat viscosity curve. These modern methods were coming into practice and would steadily increase in their application. They depended on the specific solubility of unsaturated and polar bodies in a variety of solvents, which resulted in increasing what might be called the "paraffinicity" of the oil. This treatment could be brought about by a large number of solvents, and a few of these solvents which had proved quite effective, particularly in the United States, were nitrobenzene, phenols, sulphur dioxide mixed with benzolene, cresols, furfural, and $\beta\beta$-dichlorethylether. (Discussion before Section G—Engineering of the British Association Meeting at Norwich, abstracted through *Engineering*, vol. 140, no. 3642, Nov. 1, 1935, pp. 481–483)

MACHINE TOOLS

Hydraulic Indexing

HYDRAULIC indexing is used in the Hammond boring and reaming machine. A heavy table carrying five automobile cylinder blocks on which the machining operations are performed is automatically indexed through 72 deg by fluid motor *F*, Fig. 4, the rotation being effected through spur pinion *T* in mesh with ring gear *A* bolted to the underside of the table.

A foot pedal at the floor level sets the fluid motor in motion to carry out the indexing cycle. As the operator steps on the foot pedal, which is connected to lever *B*, Fig. 4, lock-bolt *C* is withdrawn from its guide bushing in the table which now is free to be rotated. As the bolt recedes it carries with it an integral plate *D* which operates limit switch *E*. A solenoid is energized to open valve *N* and allow oil pressure to actuate the fluid motor *F*.

When the table has revolved 72 deg, dog *G* on the underside of the table comes into contact with a plunger on valve *H* and stops the fluid motor. Subsequently lock bolt *C* snaps into engagement with a guide bushing in the table, operating the limit switch *E* through plate *D* in a direction opposite to that at the beginning of the index. This energizes another solenoid to actuate valve *O* and consequently advance the four tool heads into working position. (Harold B. Veith in *Machine Design*, vol. 7, no. 7, July, 1935, pp. 26 and 67)

METALLURGY

Cerium in a Light Alloy

A NEW alloy called Ceralumin "*C*," which consists of nickel and aluminum with a small addition of cerium has been developed by the J. Stone Co., Ltd., London. It is a casting material containing iron (about 1.2 per cent) and aluminum as the main constituent. Tests have indicated that cerium allows the beneficial mechanical effects of a high iron content to be obtained by suppressing the embrittling constituent which is otherwise likely to be formed.

The heat-treatment applicable to this alloy is quite simple. Castings are maintained at the solution temperature of 515 to 535 C for from four to six hours and then quenched in water; aging is achieved by heating to 175 C for 16 hr, followed by quenching in water. The risk of distortion at the solution temperature is no greater than that involved, for example, in heat-treating "Y" alloy at 520 C.

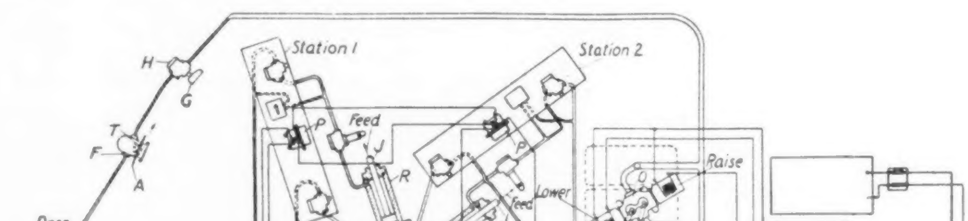


FIG. 4 BORING AND REAMING MACHINE WITH HYDRAULIC INDEXING

In the heat-treated condition Ceralumin "*C*" presents a combination of high tensile strength at ordinary and elevated temperatures, high elastic limit, high Brinell hardness, and exceptional fatigue strength of 18,500 lb per sq in. at 20,000,000 cycles. The alloy is said to be suitable for high-duty service in the form of die-castings, chill castings, and sand castings.

If, after quenching, the aging treatment is omitted, aging at room temperature takes place, and after five days a modified form of the alloy is produced having somewhat lower tensile strength but increased ductility. This modification is intended for purposes where extra toughness is required in castings, such as for shrinking-on cylinder heads where heavy stresses may be set up and a little "give" in the casting is essential. (*Machine Design*, vol. 7, no. 10, October, 1935, p. 29, 1 fig.)

MOTOR-CAR ENGINEERING

Cotal Electrically Controlled Gear Box

THE Cotal is an epicyclic gear with magnetic clutches and a simple form of remote control. It has been extensively tested in France and preparations are being made to manufacture it in England where some tests of it have been made. The chief object of those tests was to determine whether a high-power-transmission efficiency could be obtained in all ratios and whether the temperature of the box remains low during prolonged full-load operation.

The ratios in the box tested were 4.231, 2.610, 1.621, and 1.0 to one, and the transmission efficiencies with approximately full engine torque were 92, 94, 96, and 98 per cent. These figures allow for the slip in the fluid coupling which would account for nearly 2 per cent of the power-loss figures of 8, 6, 4, and 2 per cent.

During a $3^1/_2$-hr run with all the ratios in use and under almost continuous full load the temperature of the box rose to 159 F, the room temperature being 75 F. The smallness of the temperature rise, while being another indication of the high efficiency of the Cotal box, is to be attributed in part to the arrangements for maintaining a rapid flow of lubricating oil from the inside of the box where the gears are at work, to passages in the outer casing where the filter and pump are located. One of the drawings in the original article shows the outline of the box tested, and from this it is apparent that the unit is extremely compact; it is in fact considerably smaller than other gear boxes designed for a similar duty. (*Diesel Railway Traction*, *Supplement to Railway Gazette*, Oct. 4, 1935, p. 567)

Duoautomatic Hydraulic Braking

THIS is a device used on Hudson cars for 1936. Every emergency application of the hydraulic brake is backed up by a mechanical application which becomes operative when the pedal has been moved through three-quarters of its range, or in the event the hydraulic brake fails. The first part of the travel of the pedal applies the hydraulic brake. After a certain movement the pedal picks up a link connected with the mechanism that applies the emergency brake to the rear wheels. (*Automotive Industries*, vol. 73, no. 17, Oct. 26, 1935, pp. 550–552, 4 figs.)

Victor Touring Car With Airless-Injection Engine

THE first touring car fitted with an airless-injection engine to be offered to the public in England was recently demonstrated there. It consists of a horizontally opposed twin-cylinder engine in a Jowett chassis. A fuel consumption of 1 gal per 65 miles, and a lubricating-oil consumption of 1 gal per 2000 miles are claimed. Both the engine and the chassis separately have been extensively used, the former in motor-boat work.

The engine is of the air-cell type and has a cylinder bore of 80 mm and a piston stroke of 100 mm, giving a capacity of 1000 cu cm. The cylinder heads of cast iron are detachable. The cylinders are provided with removable wet liners and the pistons are of aluminum alloy with gudgeon pins of the fully floating type. (*Engineering*, vol. 140, no. 3640, Oct. 18, 1935, pp. 416, 1 fig.)

POWER-PLANT ENGINEERING

60 Per Cent Steam-Power-Plant Efficiency

THE paper claims that it is possible to organize industrial steam generation and utilization to operate at an overall efficiency of more than 60 per cent, even though the most efficient superpower stations today generate electricity at an overall efficiency of less than 30 per cent. The new higher efficiency is to be obtained by utilizing the latent heat of steam through a combination of steam-power generation and heating. Exactly how this is to be done the paper does not show, however.

It is fully realized that this ideal cannot be attained over a short period of time, but it is definitely the goal toward which effort must be made if progress is to be secured along the line of cheaper electricity and more economical working of the power plant. If this ideal is kept clearly in mind, there is little doubt that local district schemes can be developed, which will merely be an elaboration of many industrial schemes already in successful as well as economic operation.

The policy of developing steam-power schemes by districts rather than by individual industries as at present will bring with it a number of subsidiary advantages. Steam generation will be under the control of qualified engineers, and the plant will be arranged for the highest generating efficiency. Heat and power will be "on tap" not only for industrial works, but also for business houses and domestic needs; and in the latter cases there will be a considerable saving in labor and also elimination of dirt, and heating will be more efficient due to the continuous maintenance of a normal temperature. (*The Steam Engineer*, vol. 4, no. 12, September, 1935, p. 506)

Safety Valves in High-Pressure Boilers

THE safety valve was primarily developed at the time when the large water-drum boiler was principally used. In the case of such a boiler the steam can be blown off safely because the amount of water contained in the boiler is so large that when the safety valve is suddenly opened enough time is available for the feeding device to prevent the water level in the boiler from going down too much.

On the other hand, in the high-output boiler, the amount of water available is small and under certain conditions the sudden opening of a safety valve can bring about such a reduction of the water content in the boiler as to cause overheating of the tubes with all that this involves. Furthermore, when the safety valves of a high-pressure boiler are blown the action of the steam is so extraordinarily erosive as to produce lack of tightness in the valve when returned to its seat. This happens when the steam pressure is in excess of 30 atm. It is stated that when this happens it takes a week to replace the valves in order to give them a tight seat. A German device by which this condition may be avoided is described in the original article. (*Archiv für Warmewirtschaft und Dampfkesselwesen*, vol. 16, no. 9, September, 1935, p. 226)

High-Output Sectional-Chamber Inclined-Tube Doebler Boiler

THE purpose of this boiler is to combine the advantages of an inclined-tube and a vertical-tube boiler. The fundamental idea is to assure water circulation under all conditions.

In the design of the boiler particular attention was paid to the requirement that when the steam is removed and water to replace it admitted there shall be no material resistances between the sectional chamber and the boiler chamber. The circulating tube is therefore arranged so that it can be used to take steam from the forward sectional chamber while water is being added to the real sectional chamber. To do this the cross section of these tubes is made at least as large as the free cross section of the sectional chambers which they join.

In order to permit the steam generated in the boiler tubes to move as fast as possible in a predetermined direction, the bundle of boiler tubes is inclined more steeply than usual. The position of the boiler tubes at less than 45 deg was found to be the most desirable. Because of this the upward flow of steam bubbles is facilitated, and the return flow of water assured. This was done by creating a useful static head produced as a result of locating the lower boiler tube ends at a low point and making the sections of great height. With the boiler tubes set at a steep angle the static head in the upper row of tubes is not less than in the lower row of tubes. This great head on the lower ends of the boiler tubes affects water circulation favorably under all conditions, and disturbances in the flow of steam inside of the upper rows of tubes have never been observed in practice.

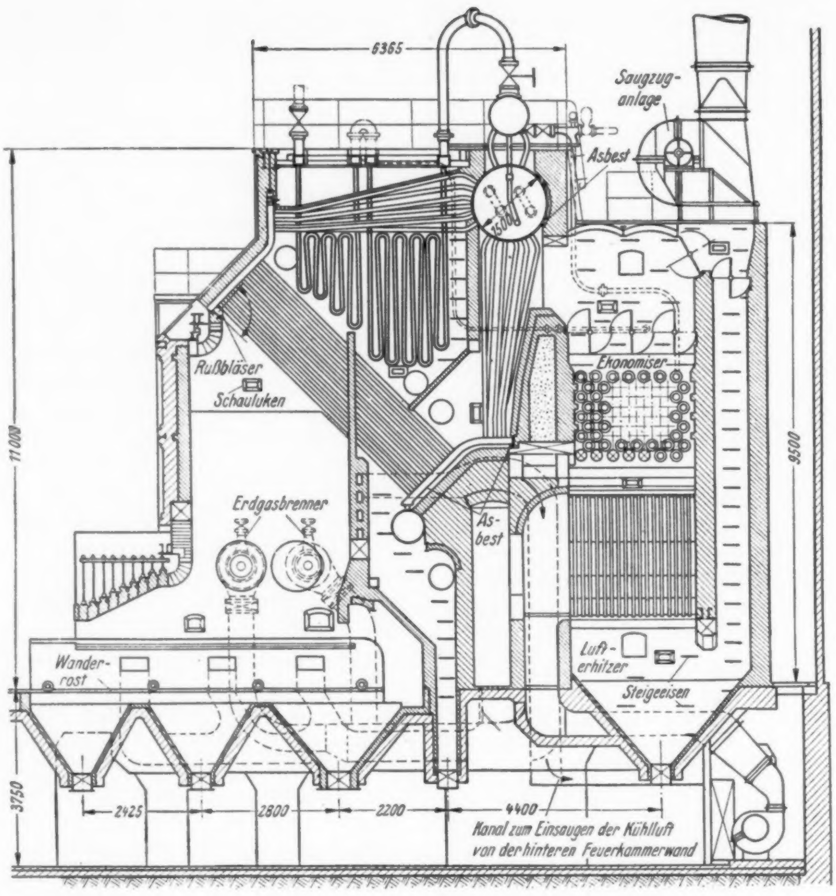


FIG. 5 DOEBLER BOILER, 23 ATM 450 C

(*Russbläser* = soot blower; *Schauluken* = peep hole; *Erdgasbrenner* = natural-gas burner; *Wanderrost* = traveling grate; *Lufterhitzer* = air preheater; *Kanal zum Einsaugen der Kühlluft von der hinteren Feuerkammerwand* = duct for taking in cold air by suction from the rear combustion-chamber wall; *Saugzuganlage* = suction draft; *Asbest* = asbestos; *Steigeeisen* = stirrup.)

ARRANGEMENT OF CONNECTING TUBES

The upper row of steam-carrying circulation tubes is located so high that under all conditions it is above the water level in the boiler drum. The connecting tubes located below it serve more for water circulation. The rearmost row of the back circulation tubes serves primarily to admit the feedwater. The other tubes of this kind are engaged in providing water circulation. The reliable supply of feedwater provided by the lower drop tube rows is assured by the installation of a properly proportioned sheet-iron baffle. The feedwater trough in the boiler drum is as long as the tube system is wide. The feedwater coming in is distributed by means of the trough over the entire width of the boiler.

There is the same number of circulation tubes front and rear, and these tubes are of equal length, thickness, and shape, there is likewise an equal number of sectional chambers. This simplifies the manufacture and facilitates replacements. The fact that all the elements are alike results in a perfectly symmetrical construction of the boiler, while the uniform distribution of heat expansion over the entire boiler is also facilitated. Furthermore, the water circulation is uniformly distributed over the entire width of the boiler, while temperatures of the heating surfaces coming in contact with water are approximately the same, and undesirable heat stresses are eliminated.

HEATING THE DOWNCOMERS

In order not to disturb the water circulation an attempt was made not to permit generation of steam in these tubes. The best way would have been to place the tubes entirely outside of the gas stream. While this step, under certain conditions, might have been fully justified, it would be going too far to use this arrangement as a basic element in every kind of boiler. In modern boiler operation there are conditions which not only permit the low heating of the downcomer, but in the interest of simpler boiler construction, make it desirable.

In the sectional boiler here described these tubes are placed in the last stack behind the boiler area, where the gases have been so effectively cooled that only a small amount of heating is provided. Moreover, the heating surface of the economizer has been so proportioned that the feedwater temperature at the entrance to the boiler is at least 30 C lower than the boiler temperature. The feedwater admitted, together with the circulating boiler water, is immediately led into these downcomers and the water is supplied with the amount of heat just necessary to bring it to the boiling temperature.

Quite a number of these boilers have already been installed and are apparently giving satisfaction, although in Ger-

many this type is as yet little known. Data of tests are given in the original article. (A. Doebler in *Archiv für Wärmewirtschaft und Dampfkesselwesen*, vol. 16, no. 9, September, 1935, pp. 233–235, 2 figs.)

SPECIAL MACHINERY

Electrography

ELECTROGRAPHY is a new method of electrostatic recording. At a meeting of physicists in Hamburg in 1928 the author presented a high-vacuum cathode-ray tube with which oscillograms were to be recorded on the surface of a body by means of negative charges of electrons. This left an invisible record which could be then "developed" by spraying over the glass surface a powder carrying positive electrical charges. At the time this process was described it had barely passed the initial stages of experimentation. Of late, however, the author succeeded in developing it to the point where the recording of electrical processes by means of electrostatic charges could be carried out

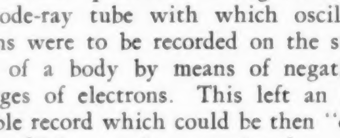


FIG. 6 APPARATUS FOR ELECTROGRAPHICAL RECORDING

in the open, which offers important possibilities for the technical and physical application of the process.

The apparatus used in this process is diagrammatically shown in Fig. 6. In principle it is comparable to the operation of three electron tubes or Braun tubes. The hot cathode K consists of a platinum strip or wire covered with barium oxide. At a distance of a few tenths of a millimeter from the cathode is located a metal screen G which has two functions to perform. In the first place, the opening of a slot limits the cross section which the stream of ions can pass and in the second place the screen operates as a grid or a Wehnelt cylinder, in that the potential induced in the screen controls the magnitude of the stream of ions. The metal plate A is the anode. Its forward surface is covered with a good insulator P, such as ebonite, $^1/_4$ to $^1/_2$ mm thick. The distance of the plate P from the metal screen is also as small as possible, say, about $^1/_3$ to 1 mm. If the cathode be heated and a potential of 500 to 1000 volts be induced for a short time in the anode, the ions flow through the opening in the grid and charge the surface of the ebonite plate. If the latter be then dusted, a clearly marked round spot is brought out. If the electrical charge on the anode be left for a longer time the bundle of ions flowing through the opening spreads out, the spot becomes greater, and finally may attain a diameter of 5 to 6 mm. On the other hand, if during the exposure of the anode and ebonite plate they are moved in their plane, the bundle of ions records a sharp line on the plate. This electrical line is the thinner the faster the anode is displaced, but at the same velocity of displacement, the thickness of the line depends on the grid voltage, and the line is the narrower the more negative the voltage on the grid has been selected. This is explained in detail in the original article which also shows samples of records. (P. Selényi in *Elektrotechnische Zeitschrift*, vol. 56, no. 35, Aug. 29, 1935, pp. 961–963, 8 figs.)

TESTING AND MEASUREMENTS

The "Relator" Speed-Checking System

STROBOSCOPES can be used both for measuring the speed of rotating parts and for checking whether this speed is right. In the latter case the stroboscope has a constant setting, in the former it has to be adjusted to suit each case, which is a time-consuming process presenting opportunity for the commission of errors. It is claimed that this particular difficulty has been overcome in the new stroboscope developed in England by A. J. Ashdown, and called the "Relator" system.

This apparatus comprises a stroboscopic device working at constant speed with high accuracy, and consisting of a "gun" which throws a whirling beam of light on to the part, the speed of which is to be checked. This whirling beam may be considered as equivalent to a stationary rate which is interrupted 3000 times a minute for the standard rate of whirl of the beam of 3000 rpm. At one point of the whirl the object toward which the beam is directed is illuminated by the light over the rest of the whirl; the light does not fall on the object. The whirling beam therefore effects the same results as when interrupted by the mechanical and electrical objections associated with high-frequency interruption of illumination.

In order to make a stroboscope of fixed-glimpse frequency applicable to shafts or other parts of machinery running at various speeds, the device makes use of numbered collars or similar indicators which are attached to the shafts or parts. Suppose that the intended speed of a certain shaft is 200 rpm. The collar applicable to this shaft has the number 15 marked at equally spaced intervals fifteen times around its periphery. As an alternative an equal number of reflectors which catch the light from the stroboscope and return it to the observer's eye may be provided. Since a 200-rpm shaft makes one-fifteenth of a turn in one-three thousandth of a minute, it is clear that if the shaft is running at its intended speed, the numbers of reflectors on its appropriate collar will appear stationary when illuminated 3000 times a minute. If it is running slower or faster the numbers will appear to move around against or with the rotation of the shaft. If it is desired to determine by how much the shaft is running slow or fast, it is sufficient to count the rate at which the numbers disappear from view for the apparent rotary speed of the numbers equal to the discrepancy between the actual and the intended speeds of the shaft. The device may be used to measure any speed of the shaft, such as 110 rpm and not merely an exact submultiple of 3000. (*The Engineer*, vol. 160, no. 4162, Oct. 18, 1935, p. 409, 1 fig.)

VARIA

The Machine Age in the Glass Industry

IN A presidential address to the Fourth Glass Convention (Great Britain) the author says that he believes that the universal adoption of mechanical processes is bound to increase unemployment unless sufficient machines are installed to absorb all those who were previously engaged in the hand-operated processes.

The glass industry is in a peculiar condition because the question of the proposed compulsory introduction of the four-shift system into glass works by means of an international convention has been before the International Labor Conference at Geneva. In 1934 the convention was adopted by the Conference prescribing, as far as sheet-glass works were concerned, a four-shift system, each shift of eight hours' duration and the hours averaging 42 per week taken over a period of four weeks. The author tells the experience of his firm in the plate- and sheet-glass industry.

The following comparative results of the six months prior to and the six months after the inception of the scheme are reported. The reduction in hours per person was 10 per cent. The in-

crease in output was 15 per cent (trade actually improved in this period). The increase in the number of employees was only 8.4 per cent and represented in actual numbers 500 men and women. It should also be observed that before the scheme many men were on short time. The output value per man-hour went up 11.4 per cent. The average weekly earnings were unchanged. The scheme has now been adopted as permanent, and it can be truthfully said that the employee is happy because, although his wages have not been affected, he is enjoying greater leisure. In this particular case the employer is also able to say that his costs have not been increased, though one should draw attention to the 15 per cent increase in total output which has to some extent obscured the issue. If it is possible to apply this system to one part of the glass industry, it is worthy of serious consideration by others.

The author stresses the great importance attached to being able to consider such problems as these in conjunction with representatives of the labor in the form of the Plate and Sheet Glass Industrial Council, which enables not only problems concerning hours of employment and rates of pay in the industry to be fully examined by both sides of the table, but also frank discussions from time to time on the state of the industry itself and the conditions of world trade generally.

The next subject discussed is mechanization and quality of product. The author believes that improvements in design of mass-produced articles are both possible and desirable. (Geoffrey L. Pilkington, *Journal of the Society of Glass Technology*, vol. 19, no. 75, September, 1935, pp. 106–111)

WELDING

Forgeability of Welded Joints

THIS investigation was to determine what influence forging has on the quality of welded joints, and, in particular, how the heat of forging and the deformation in forging, the composition of the welding rod, and the character of the welding process react on the forgeability of the joint. Two testing processes have been developed to determine the forgeability of a weld in the laboratory and in the field.

This is quite an extensive paper, and among other things it discusses the matter of forgeability as a function of the forging heat. The influence on forgeability of the carbon content in the welding rod of the manganese content therein. The method for determining the forgeability of welds is described in the original article.

The conclusions to which the author comes is that in the case of electric autogenous and atomic arc welds with unalloyed uncovered welding rods tensile strength is not improved by forging. The angle of bend in the case of an electric weld forged at 800 to 700 C is somewhat lowered because of critical deformation, but increases as compared with unforged samples when the weld has been forged at a higher temperature. In the case of autogenous and atomic arc welds there is no improvement at all, due to the fact that the test pieces as delivered have already a bend angle of 180 deg.

The notch toughness of electric welds with uncovered rod is lowered by forging because of the high content of oxygen and nitrogen. In the case of autogenous and atomic arc welds forging at 800 to 700 C produces at first a reduction of notch toughness because of critical deformation. By forging, however, at 150 deg C the notch toughness improves materially because of grain refinement, but forging at still higher temperatures makes matters worse again because of the appearance of coarse grains. With the deformation of 20 to 40 per cent the same static and dynamic values have been obtained for all kinds of welds.

In practically every case where welding rods with higher carbon and manganese contents have been used, forging at 1050 to 950 C produced a mechanical improvement in practically every case. From a picture of rupture of forged test pieces made from pure welds, and by the determination of the work of deformation, it becomes possible to determine in a laboratory the degree of improvement of test pieces by forging. It appears that up to a forging temperature of 1050 to 950 C forging produces an increase in the work of deformation, while if the forging temperature is in excess of 1050 C, work of deformation decreases.

Welded joints made with welding rods of higher carbon and manganese content, reach the highest degree of forgeability when the addition of alloying elements produces a more powerful deoxidation of the weld. It has been also found that atomic arc welding produces the highest degree of forgeability, autogenous welding a medium, and electric welding with uncovered rod the lowest degree of forgeability. (Heinz Becker in *Autogene Metallbearbeitung*, vol. 28, no. 13, July 1, 1935, pp. 193–202, 27 figs.)

Welding and Failure of Machinery

THIS following editorial is based on annual reports of the British Engineering Insurance Company:

The introduction of welding into machine construction has produced a possible new source of failure, as is demonstrated by the details given in the report under notice, concerning the failure of a motor shaft, due to the effect of the welding-on of fan-blades. Here, rupture occurred on the shaft at the root of one of the blades, after 12 months' service, and it is reasonable to assume that the velocity of rotation was fairly uniform, since the shaft was driven by an electric motor. Moreover, it was found that independent cracks had started in line with five of the six blades, so that the trouble was not confined to one weld that might have been faulty. Although the metal proved to be sound, the break involved the tearing away of part of the shaft and a complete blade, whence it is possible to infer that the vibration of the rotating blades was the means of producing an increase of stress, due to the reflection of the stress-waves at the interface of the welded and parent metals. The phenomenon of reflection would be affected by the emulsified condition of the pearlitic structure found under each weld, for the original interfacial conditions are naturally modified by heat-treatment of any kind, and by the presence of contraction cracks. Such discontinuities in a metallic structure would be partially removed by heat-treatment, but it is not always easy to effect the necessary treatment where a large casting or shaft is involved, for which reason there is a need for research into the transmission of stress-waves across the interface of welded materials. The report also contains an account of the failure of shafts in the consideration of which attention might be given to the examination of the transmission of stress waves along a shaft carrying a massive flywheel, which, in acting as a reservoir of energy, imposes an alternating torque on the shaft. Since it is by no means easy to treat the practical problem along mathematical lines, it is very much to be hoped that Professor Coker's photoelastic method will subsequently be applicable to the general problem of stress waves. Such an experimental procedure may elucidate the significance of the fact that a number of the failures occurred on the shafts in the neighborhood of a flywheel, or a crank-arm, which corresponds to a sudden change of load and of cross section in the path of a wave traveling along a shaft. (Editorial in *Engineering*, vol. 140, no. 3641, Oct. 25, 1935, pp. 449–450)

LETTERS AND COMMENT

Brief Articles of Current Interest, Discussion of Papers, A.S.M.E. Activities

Fabricated Housing

To the Editor:

The article on "Prefabricated Housing" which was published in the September, 1935, issue of Mechanical Engineering points out the various economic factors underlying the demands for factory fabrication of houses. It has been stated that three-fourths of all the families in this country can afford no more than $25 a month for shelter. It is the writer's belief that the only type of house which can be purchased at this price and which can be prefabricated completely is one evolving naturally from the house car or automobile trailer. This substitute for the conventional home on a fixed site conceives the house and furniture as a unit completed in the factory, and delivered ready for immediate occupancy on a basis similar to that on which the automobile is purchased. With these thoughts in mind, the writer has designed two types of prefabricated houses.

The first of these is a trailer-type $1^1/_2$-ton house with three rooms and a bath. Sewer, gas, water, electrical, and telephone connections can be made to these utilities through a single coupling. On the first floor of this unit is an 8 by 12-ft cabin, a 4 by 12-ft galley diner, a dressing room, and a 3 by 8-ft combination bath and laundry, while on the second floor is an 8 by 12-ft bedroom incorporating a built-in means of maintaining the low overall height of the house. The frame of the house, constructed of wood and steel, is supported by the individually sprung wheels attached directly to the trussed side walls which are covered with a weather-faced hot-plate plywood material. This design has been designated as the "Nomad" unit by the writer.

The second house designed by the writer is called the "Mobile House" and can be built with as many as ten rooms and two baths. The central structure of this unit contains four rooms and a bath and has 600 sq ft of floor space. There is an 11 ft 3 in. by 16-ft living room, a kitchen containing an electrical refrigerator and an oil-heating unit, two bedrooms on the second floor, a complete bathroom, and a laundry with an electric washing machine. This unit weighs 4 tons and can be moved by truck over an improved highway by special permit. It is designed so that it can be set up on a foundation of hidden concrete wheels if it is to be sold as chattel or mounted on four steel posts. The frame of the house is constructed of wood and steel and is designed with bridge-truss walls so that it can be placed on the foundation posts or over a basement on a continuous wall. Various hoods, porches, pergolas, single rooms, and second-story units may be added until the house becomes a ten-room unit with two baths. The central four-room unit, however, is standard and contains all the complex and costly parts of the structure. The house is designed so that its structural units can be jig-cut and jig-assembled in the factory. Units needed for erecting more than the four-room central structure are stored in the central structure while it is being moved to the home site and there they are removed and assembled.

One of the "Mobile" houses has been erected in Flint, Mich., and has been exposed to climatic conditions long enough to indicate what problems must be solved by manufacturers of prefabricated houses. The great differential between inside and outside temperatures in severe climates will result in the collection of condensation moisture on the thin plywood walls of prefabricated structures to an even greater extent than on the walls of the conventional house. The plywood wall of the prefabricated house with its joints closed with glue or mastics is exceptionally liable to damage from this source. Moisture accumulated during the winter between the walls of prefabricated houses is apt to cause serious damage to the plywood structures. In the "Mobile" units described by the writer double air spaces have been utilized to eliminate this trouble. The problem of damaged plywood exteriors, caused by the disintegrating effect of sunlight, moisture, expansion, and contraction, must also be met satisfactorily by the manufacturer of prefabricated houses. This problem has been solved in the construction of the "Mobile" unit by utilizing a special type of fiber-board exterior.

The writer is of the opinion that the solution of the low-cost-housing problem lies in manufacturing a complete house which is strong and light enough to be delivered cheaply over a considerable radius and which can be sold at a cost which the lower-income groups can afford to pay.

Corwin Willson.[1]

A Modern Dust Collector

To the Editor:

A number of considerations have been introduced by H. Van Tongeren in his paper[2] which warrant careful study by the power engineer interested in the removal of fly ash from flue gases. One fundamental consideration in any attempt to solve this problem requires an economic solution by carefully comparing the lowered nuisance factor, resulting from a decrease in particle size, with the increased first cost and operating expense involved in collecting such smaller particle sizes.

Any attempt to by-pass this problem by considering only total collection efficiencies does not really simplify it because the investment and operating expense necessitated by a given total efficiency will depend on the distribution of particle size in the fly ash. This efficiency will be higher for increased proportions of very fine particle sizes. Thus, the final analysis still necessitates the weighing of increased cost against the lowered nuisance effect by a decrease in the particle sizes allowed to escape to the atmosphere.

Irrespective of the solution decided upon, the engineer is still confronted by the fact that some particles will escape with the flue gases, inasmuch as any attempt to collect them would be prohibitive. How does the difficulty of collection increase with decreasing particle size, and what factors are involved? Such questions can best be answered from a study of Stoke's law. This law gives the rate of fall of spherical particles un-

[1] Building Research, 318 Welch Blvd., Flint, Mich.

[2] "A Modern Dust Collector," by Herman Van Tongeren, Mechanical Engineering, vol. 57, December, 1935, pp. 753–759.

der the influence of gravity in terms of physical constants, and therefore, it applies primarily to settling chambers. However, it can readily be extended to cover centrifugal separators, which are adapted to separate smaller particles from larger gas volumes than can be handled in settling chambers. While Stoke's law applies only to spherical particles, other particles can be included in the analysis by defining equivalent spherical particles which would fall at the same rate in still air.

The rate of fall of spherical particles in still air as given by Stoke's law is

$$v = \frac{2}{9}r^2\left(\frac{w - w'}{n}\right)g \ldots\ldots [1]$$

where v = the rate of fall of spherical particles in still air, r = radius of an equivalent spherical particle, w = specific weight of the particle, w' = specific weight of gaseous fluid, n = viscosity of gaseous fluid, and g = acceleration due to gravity. Formula [1] can be adapted readily to centrifugal separators by replacing the acceleration of gravity g by radial acceleration. The rate of fall then corresponds to the entrainment velocity which will support the particle against the radial acceleration. Formula [1] then becomes

$$v = \frac{2}{9}r^2\left(\frac{w - w'}{n}\right)\left(\frac{V^2}{Rg}\right)g \ldots [2]$$

where V = tangential velocity of the particle, R = radius of curvature of the path, and the other terms are the same as given previously. It is convenient to divide the radial acceleration V^2/R by the acceleration due to gravity g, thus obtaining a pure ratio defining a separation factor which indicates how many times gravity is multiplied in the centrifugal apparatus.

Formula [2] shows the qualitative relationship between the various physical factors involved. In order to obtain a quantitative basis for judgment, Table 1 has been prepared giving the entrainment velocity of equivalent spherical particles of unit density through air at 212 F when the separation factor is one thousand times gravity. By observing the relationship in formula [2], the entrainment velocity under any other conditions can be readily determined. It is to be noted that the viscosity of the entraining gas varies as the square root of the absolute temperature.

Table 1 illustrates the difficulty of separating single isolated particles from a large gas stream, and how this difficulty increases with decreasing particle size. In addition, it must be kept in mind that the practical solution embodied in the equipment must be such that the theoretical conclusions can be closely approximated. In this connection, the solution proposed by Mr. Van Tongeren merits careful consideration.

TABLE 1 ENTRAINMENT VELOCITIES OF PARTICLES OF UNIT DENSITY THROUGH AIR AT 212 F

Diameter of particle			Entrainment velocity at
Microns	In.	Mesh	1000 g, fps
104	0.0041	140	860.00
100	0.0039	...	797.00
74	0.0029	200	435.00
44	0.0017	325	154.00
20	0.00078	625	31.80
10	0.00039	1250	7.95
5	0.0002	2500	1.99
2	0.000078	6250	0.32
1	0.000039	12500	0.08

Some questions have been raised as to the range of particle size for which formula [2] based on Stoke's law still holds in centrifugal collectors. In connection with applications where limitations as to permissible capital outlay and power costs for operation do not yet enter, actual operating experience has been obtained which indicates that this range of particle size can be extended below 5 microns.

In the operation of the micronizer reduction mill, controlled by International Pulverizing Corporation, the grinding energy is furnished directly by high-pressure steam or air with initial temperatures up to 750 F. The air or steam is also utilized for air-sweeping the grinding zone and classifying the product. In certain instances, the high whirling motion of the gas stream is utilized for collecting the product in a centrifugal separator of the cyclone type. In commercial operation, a collection efficiency of 98 per cent has been secured for a product having a maximum particle size of 5 microns, the efficiency being determined by weighing the raw material and collected product.

Referring to formula [2], the radius of curvature R for the collector was $2^1/_2$ in., while the tangential velocity V resulted in a pressure drop exceeding 1 lb per sq in. Under these conditions, and taking into consideration the density of the material, the figures for entrainment velocity given in Table 1 would probably be multiplied by a factor of at least 25. The collection of 5-micron material then becomes predictable from formula [2].

MARCEL A. LISSMAN.[3]

[3] Consulting Engineer, International Pulverizing Corporation, Camden, N. J.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information on the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following are records of the interpretations of this Committee formulated at the meeting of December 6, 1935, and approved by the Council.

CASE No. 756 AND CASE No. 757

(Annulled)

CASE No. 808

(Interpretation of Par. H-24)

Inquiry: (*a*) May the provisions of Par. P-216 be applied to heating boilers as an extension of the provisions of Par. H-24?

(*b*) In the case of welded low-pressure heating boilers having unflanged heads, may the provisions of Par. H-24 be applied? If not, what would the requirements be with respect to the area to be stayed and what would be the maximum height of the segment above the tubes?

Reply: (*a*) The provisions of Par. P-216 may be applied to the design of low-pressure heating boilers having flanged heads.

(*b*) Excepting only the allowance of

2 in. above the tubes, the provisions of Par. H-24 may not be applied to the unflanged flat heads of welded heating boilers with the exception that unflanged flat heads inserted in the shell at least

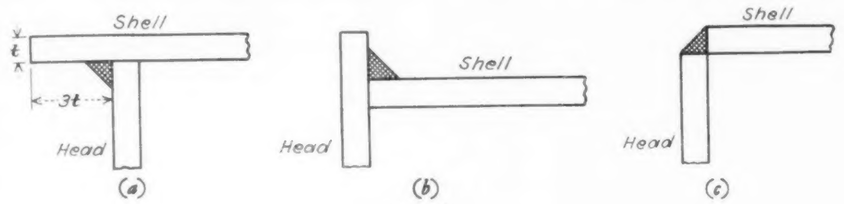


FIG. 31

$3t$ (see Fig. 31(*a*)) may be considered the equivalent of flanged heads (t = shell thickness). For flat unflanged heads not inserted in the shell (see Figs. 31(*b*) and (*c*)), the maximum distance from the top row of tubes to the shell must not exceed $1p$ without staying.

CASE No. 813

(*Interpretation of Pars. P-198a and P-268a*)

Inquiry: (*a*) Will a flat head having a flange which is screwed over the end of a shell, pipe, or header be considered acceptable under the rules in Par. P-198*a*?

(*b*) Will a head of this type be subject to the limit of 100 lb per sq in. working pressure specified for threaded joints in Par. P-268*a*?

Reply: (*a*) Flat heads attached in the manner described may be considered equivalent to either sketch (*c*) or (*j*) of Fig. P-14$^1/_2$ provided all other requirements thereof are met and all possible means of failure of the threaded joint, either by shear, tension, or compression, due to the hydrostatic end force, are resisted with a factor of safety of five.

(*b*) The limitation referred to in Par. P-268*a* is not intended to apply to threaded joints not connected to external piping.

CASE No. 814

(*Interpretation of Pars. U-69 and U-70*)

Inquiry: Do the plate-thickness limitations of $1^1/_2$ in. in Par. U-69, and $^5/_8$ in. in Par. U-70 apply to all plates that make up the heads and shell of the vessel, or do they apply only to the shell thickness?

Reply: It is the opinion of the Committee that the plate-thickness limitations of Pars. U-69 and U-70 apply to shell plates, also to heads when fabricated of more than one piece. They do not apply to heads formed from a single plate.

CASE No. 810

(Annulled)

CASE No. 815 AND CASE No. 816

(In the hands of the Committee)

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Reducing Industrial Power Costs

REVIEWED BY H. DRAKE HARKINS[1]

REDUCING INDUSTRIAL POWER COSTS. By David Moffat Myers. McGraw-Hill Book Company, Inc., New York, 1935. Cloth, $5^7/_8 \times 9$ in., 378 pp., 35 figs., supp. plate, $4.

AS stated by the author, "the object of this book is to give the business and industrial executive unprejudiced information of the kind he wants and needs, virtually, a short intensive course on industrial steam and power engineering from the economic viewpoint." The author has ably reached his objective but this reviewer questions if any appreciable number of industrial executives can be persuaded to read its 366 pages. Industrial power engineers might well exert some effort to persuade them to do so. Failing this, they can make good use of the book by using it as a reference work for preparing and presenting "dollar arguments" to management. Likewise, the recent engineering graduate (and some not so recent) should read this book to learn the proper balance between technology and the dollar in every-day engineering work, as it is set forth emphatically in every page of this book.

Chapter 24 is devoted to power facts and data and makes interesting reading for the power engineer. The author shows by comparison and by statistics, that power cost, although relatively an unimportant part of industrial total cost, is a very important part of net profit even in prosperous years. Unfortunately, this important relation is also borne by packaging, advertising, and so many other industrial costs that we may doubt that it will do much to impress management. This reviewer finds management easier to convince by the argument that profits made in the power plant continue through good years and bad and are relatively independent of sales effort, changes in style, and buying habits and the other adverse factors which affect the sale of commodities.

The author has included a chapter putting "hydro" in its proper place.

The author has wisely included his power-loss check chart because the book would not be complete without it, although this material has been published before.

In his attempt to simplify steam-power-plant engineering for the nontechnical reader, the author has done an excellent job but occasionally permits his own technical knowledge to lead him away from that reader's viewpoint. For example, he might have spared those readers some of our technical idiosyncrasies, especially "equivalent evaporation" and "factor of evaporation." Boiler efficiency can be explained without these terms.

[1] Industrial Engineer, E. I. du Pont de Nemours & Co., Wilmington, Del. Mem. A.S.M.E.

Key to Economic Progress

INCOME AND ECONOMIC PROGRESS. By Harold G. Moulton. Brookings Institution, Washington, D. C., 1935. Cloth $5^1/_4 \times 8$ in., 192 pp., $2.

REVIEWED BY FRANK CLAY CROSS[2]

THE Brookings Institution, Washington, D. C., which the author of the book under review serves as president, was organized to conduct economic and governmental research. It is a nonprofit corporation devoted to public service, and is financed largely through grants from philanthropic trusts. The Maurice and Laura Falk Foundation, of Pittsburgh, Pa., provided the funds for a study of income and economic progress which has just been completed after three years of investigation, and which has provided material for three books already published, "America's Capacity to Produce," "America's Capacity to Conserve," and "The Formation of Capital."

This study began with a comprehensive survey of America's productive capacity. The purpose of the survey was not to estimate what production might become under some fanciful system but the practical possibilities under present techniques. The second phase of investigation had to do with consumption habits, trends, and possibilities; the third, with the processes whereby more factories and other plants and equipment are financed from savings; the fourth, which completed the work, with the question of how the distribution of income is related to the rate of economic progress.

The chief impediment to the nation's economic progress, the Brookings report declares, is to be found in the growth of measures and policies which have hampered the free functioning of the competitive system. In the past half century, a definite tendency has arisen to protect business enterprises by stabilizing the price structure. Corporate consolidations, pools, trusts, cartels, and trade associations have been established to hold competition in check. Then came the NRA which undertook, through Code Authorities, to maintain certain price levels by the force of public opinion.

This active philosophy, the Brookings economists believe, is responsible, in no small measure, for the difficulties which business and industry have experienced in recent years. "Particularly since the World War, and often with the assistance of governments," the report asserts, "efforts have been going forward to 'stabilize' existing business situations and to underwrite the prosperity of individuals, corporations, or large business groups by attempting to stabilize prices. We believe the evidence is clear that such attempts, however well intentioned, are dangerously short-sighted. They result inevitably in 'freezing' situations which in the interest of economic progress must be left as fluid as it is possible to make them."

The way forward suggested by the study is indeed a very simple one when compared with many of the intricate, or radical, schemes which have been promulgated. It is simply a return to wholesome competition. To reestablish that condition the first move must be to eliminate all the devices and agencies which have been created to maintain the status quo, and to make lower prices—not higher—the goal of business and industry. The conclusion is reached that the key to economic progress is to be found in long-term reduction of prices, as technological advance makes it possible. The force to insure the reduction is competition.

The efforts of certain groups to obtain the benefits of improved efficiency in higher wages have resulted in economic disparities which arbitrary wage increases unavoidably create between urban and rural groups. These disparities are not alone the misfortune of the agricultural communities; their effect is adverse to all industry. The survey significantly points out that 40 per cent of the entire population of America lives either on farms or in towns of less than 2500 inhabitants. If these potential buyers are to have their purchasing power augmented as productive efficiency is increased, they must get it through lower prices.

Another large group which falls outside the wage group and hence must retreat before any artificial increase in prices is made up of small shopkeepers, professional men, and various other workers who number approximately twenty million.

The fallacy of curtailing production by the establishment of quotas, the restriction of working hours, or the control of new capital development is also clearly revealed. Whatever may be said in favor of such measures as a means to meet temporary emergencies, the report declares, in the end they can only lead in the direction of national impoverishment. Even in the boom years, preceding 1929, millions of American families were undersupplied with goods. More than 16 million families had incomes of $2000 or less; six million received less than $1000. That these families wanted more goods than they were able to buy at prevalent prices is hardly open to question.

The popular notion that the problem can be solved by bonuses, doles, or any other government largess, or by shorter hours of labor which would distribute more money to more workers without a corresponding increase in production, confuses *money* income with *real* income. Money is valueless except as it represents property and merchandise to supply the needs and desires of its possessors.

There never has been a state of overproduction in America. On the contrary, production has never equaled the needs and desires of the entire population. The trouble has been a matter of distribution.

In lucid terms the report shows that the proposal to shorten hours of labor in proportion to increases in man-hour efficiency, if carried into effect, would definitely prevent any future improvement in the standard of living. The proponents of the plan argue that since production per worker increased about 71 per cent in the 14 years between 1919 and 1933, work which required about 52 hr to complete in 1919 can now be done in 30 hr or less. Therefore the universal 30-hr week is advocated to relieve present unemployment. "The adoption of such a principle," the Brookings economists declare, "would mean a freezing of standards of living in general at 1919 levels." On the basis of present prices the total national production in 1919 was considerably less in per capita terms than the low production of 1934. The program thus calls specifically for a level of national production not only below that in the boom year, 1929, but also below that obtaining in the depression period. When carefully analyzed, it says to labor:

"You can reap henceforth no advantage from technological progress, other than greater leisure; you shall have no choice as between more goods and services and more spare time; only in so far as you may be able to obtain a larger share of a fixed total of wealth produced will it be possible for you to enjoy more of the material comforts and conveniences of life."

The unsoundness of the proposal for shorter hours of labor as an impetus to stable economic progress is identical with the fallacy that underlies all other plans to establish prosperity by such methods as bonuses to soldiers, and pensions for the aged—provided they cease to work. The proponents of such plans see more money in circulation through trade channels, constituting a greater market demand for new production.

[2] Denver, Colo.

They do not see that the production of goods to meet the new demand would be curtailed by the very measures which would increase the monetary income.

In a similar way the successful achievement of any program, sponsored by farm organizations or business groups, to obtain a higher money income by selling less goods at higher prices can only reduce the aggregate real income of the nation.

Among the other popular schemes to correct economic maladjustment, which are analyzed by the Brookings study, is the "share the wealth" proposal. It is shown, first, that any attempt, short of communism, to equalize the ownership of wealth would be entirely futile. Only a small fraction of our national wealth is actually divisible. The greater part consists of such property as railway tracks, telephone lines, power and gas plants, factories, warehouses, pipe lines, mines, and office buildings. If any division were to be made of such properties it would have to be accomplished through the distribution of shares of stocks which could be done only under a form of government far different from ours of today.

The equalization of incomes would be equally impracticable. Those who advocate such a plan erroneously maintain that poverty could be relieved by utilizing the salaries of corporation officials and the income derived from investments, for the benefit of the masses. The amount available for distribution under such a plan, the report points out, would be less than 18 billion dollars, which would amount to about $140 per year per capita.

There is just one logical way to insure prosperity, and that is to adopt a policy which will enable more people to purchase more goods, and simultaneously promote the production of more goods for them to buy. The solution of the problem, the Brookings economists assert, is the steady lowering of prices as increased productive efficiency makes it possible—a recommendation which takes direct issue with much of the economic philosophy now current.

Such a program would naturally encounter few, if any objectors among the consumer class. There is a widespread belief among producers, however, that profits vary directly with prices, and hence that a decrease in prices would mean a decrease in earnings. The history of business enterprise disproves that theory, according to the Brookings study. In every instance where prices have been reduced progressively as technological improvements were made, profits, for business as a whole, have taken care of themselves. The two decades between 1870 and 1890 are cited as a period of rapid technological advance in which wholesale prices and transportation rates were greatly reduced without impairing profits. Between 1922 and 1929, however, the story was different. In the latter period efficiency, as measured by the productive ability of the individual worker, increased about 18 per cent in all industry, and about 25 per cent in manufacturing. The prices of manufactured goods, however, declined only about 5 per cent, and the prices of raw materials remained practically stationary.

Lower prices would automatically accelerate buying, and greater production would be necessary to meet the new demand. It is a well-known industrial principle that the unit costs of production vary inversely with the volume of goods produced.

There has never been a time in America's economic history when the needs and desires of the population for the goods of industry did not far exceed production. Yet, even in prosperous 1929, 20 per cent of the nation's plant ran to waste for lack of market. The explanation of that fact, according to the Brookings report, lay simply in the failure of industry to pass along the savings of efficiency to consumers in lower prices. This process is supposed to be automatic under capitalism, but its operation has been artificially blocked to such an extent that our whole economic structure has become impaired.

If prices had declined with the increase of industrial efficiency, between 1922 and 1929, the new market for goods among consumers in the lower-income brackets would have necessitated the construction of new factories and other plants to keep production apace with demand. More labor would have been needed to man them; more raw materials would have been required. Thus money, in the form of wages to workers and disbursements to the producers of raw materials, would have gone into the pockets of more and more potential consumers. Since consumer demand was insufficient, however, additional plants became unprofitable. Hence savings went into speculative bidding-up of outstanding securities and other property. The balance between production and consumption was far out of adjustment.

The real income of the nation is its production. Money is merely a symbol. A program of lower prices, according to the Brookings study, would inevitably result in a greater demand for goods. This greater demand would speed the wheels of industry. Profits would increase proportionately. More workers would be needed in factories, and in all branches of the production of raw materials, mining, lumbering, farming, etc. The benefits would be limited to no one group or class, but every one would share them; and the nation could look forward to a consistent and healthy growth in every division of its economic structure.

Books Received in Library

AERODYNAMIC THEORY, a General Review of Progress under a Grant of the Guggenheim Fund for the Promotion of Aeronautics. Vol. 5, Div. N-O. Edited by W. F. Durand. Julius Springer, Berlin, 1935. Cloth, 6 × 9 in., 347 pp., diagrams, charts, tables, 20 rm. (15 rm. to U. S. A.) The treatise of which this volume is a part, is intended to provide the aeronautic designer and student with a reasonably adequate presentation of background theory. The first of the two monographs presented is the "Dynamics of the Airplane," by Professor B. Melvill Jones. It is chiefly devoted to a discussion of the experimental data, symbolic analyses, and numerical computations that are required for the study of small disturbances from straight flight. The second monograph, by L. V. Kerber, discusses various methods for estimating the performance of airplanes, or the consequences of changes in their design, prior to their construction.

A.S.T.M. STANDARDS ON TEXTILE MATERIALS, prepared by Committee D-13 on Textile Materials, Specifications, Tolerances, Methods of Testing, Definitions and Terms. American Society for Testing Materials, Philadelphia, October, 1935. Paper, 6 × 9 in., 246 pp., illus., diagrams, charts, tables, $1.50. This pamphlet contains all of the specifications and tests approved by the American Society for Testing Materials, together with other infor mation of use to users of textile materials. The book includes various new and recently revised standards, some of which are published for the first time.

ANALYTICAL AND APPLIED MECHANICS. By G. R. Clements and L. T. Wilson. McGraw-Hill Book Co., New York and London, 1935. Cloth, 6 × 9 in., 420 pp., diagrams, charts, tables, $3.75. This text aims to provide a simple but rigorous discussion of the mathematical theory necessary for a thorough first course in mechanics, and to present a wide variety of applications, interesting in themselves, and of direct usefulness to students of engineering. Both graphical and analytical methods are discussed. Many problems are provided.

DAMPFTURBINENKRAFTWERKE KLEINER UND MITTLERER LEISTUNG. By F. Aschner. Julius Springer, Berlin, 1935. Cloth, 6 × 9 in., 145 pp., diagrams, charts, tables, 9 rm. The construction of steam-turbine electric plants is here considered with reference to the requirements of the smaller installations, with generating units up to 5000-kw capacity. Attention is paid to economic and mechanical questions, to boiler and turbine equipment, costs, and operating costs.

HISTOIRE DE LA LOCOMOTION TERRESTRE. Les Chemins de Fer. Texte et Documentation. By C. Dollfus and E. De Geoffroy. *L'Illustration*, 13 rue Saint-Georges, Paris, 1935. Leather, 11 × 15 in., 376 pp., illus., maps, charts, diagrams, 195 fr. To celebrate the centennial of the first European railway system, *L'Illustration* has issued a handsome folio, describing the development of the railroad from its beginnings to the present day. An outstanding feature of the work is the illustrations, numbering several hundred and including many in color. These comprise reproductions of contemporary drawings and photographs and give a vivid picture of developments. The book will delight every student of railroad development.

INTRODUCTION TO ATOMIC PHYSICS. By J. Thomson. Methuen and Co., London, 1935. Cloth, 6 × 9 in., 228 pp., diagrams, charts, tables, 10s 6d. The author has endeavored here to supply a concise, logical account of the fundamental facts and theories of the subject, which will give the reader a clear idea of the essential simplicity of atomic phenomena and show in proper perspective the new principles that modern investigations have brought into being. The more important experiments which form the basis for the various theories are first described. This is followed by a summary of Bohr's conceptions and an account of elementary wave mechanics. There is a final section which applies the theory to questions of atomic, nuclear, and molecular radiation.

INTRODUCTION TO THE THEORY OF FUNCTIONS OF A COMPLEX VARIABLE. By E. T. Copson. Clarendon Press, Oxford, England, Oxford University Press, New York, 1935. Cloth, 6 × 9 in., 448 pp., charts, diagrams, tables, \$8.50. This text, which is based on a course of lectures given to undergraduates at the universities of Edinburgh and St. Andrews, is intended to provide an easy introduction to the methods of the theory of functions of a complex variable. The first six chapters contain an exposition of the properties of one valued differentiable functions of a complex variable. In the rest of the book the problem of conformal representation, the elements of the theory of integral functions, and the behavior of some of the special functions of analysis are discussed.

J. & E. HALL, Ltd., 1785 to 1935. By E. Hesketh. University Press, Glasgow, 1935. Cloth, 6 × 9 in., 58 pp., illus., diagrams. The former chairman of this firm has written a brief account of its history. Founded in 1785, it was a pioneer in the manufacture of paper-making machinery, marine engines, and refrigerating machinery. Richard Trevithick was employed at these works during the closing period of his life. The little book is attractively printed and contains a number of interesting illustrations.

MACHINERY'S YELLOW-BACK SERIES. *Machinery*, 148 Lafayette St., New York, 1935. Paper, 5½ × 8½ in., 14 to 22 pp., illus., diagrams, charts, tables, \$0.15 each; 8 for \$1. This series comprises fifty pamphlets, each of which discusses a specific topic of interest to machinists and mechanical engineers. Each pamphlet presents the essential facts in a concise statement, usually about fourteen pages long. The information is specific and practical, and in many cases is not easily available elsewhere. A wide scope is covered, including advice on electric motors, change gears, patents, plastics, steels, welding, brazing, bearings, and many other subjects.

MATERIALS TESTING, Theory and Practice. By I. H. Cowdrey and R. G. Adams. Second edition. John Wiley & Sons, Inc., New York, 1935. Cloth, 6 × 9 in., 144 pp., illus., diagrams, charts, tables, \$1.75. This book is intended to provide those taking a laboratory course in the study of materials under stress with a discussion of the methods commonly used for testing and of the fundamental principles involved. Basic methods of attack and interpretation are indicated. The new edition has been brought up to date, and a chapter on the testing of concrete added.

THE METAL—IRON. (Alloys of Iron Research, Monograph Series.) By H. E. Cleaves and J. G. Thompson. Published for the Engineering Foundation by McGraw-Hill Book Co., New York, 1935. Cloth, 6 × 9 in., 574 pp., illus., diagrams, charts, tables, \$6. This monograph is the fifth of the series prepared by the Alloys of Iron Research. It provides a review of the available information on the preparation and properties of metallic iron of high purity. It therefore supplies the best approximation of the properties of pure iron that can be presented and is a basis for the other monographs in the series. An extensive select bibliography, containing over one thousand references, is included.

MOLYBDENUM STEELS, Their Manufacture and Application. By J. L. F. Vogel and W. F. Rowden. High-Speed Steel Alloys Ltd., Widnes, England, 1935. Leather, 7 × 10 in., 103 pp., illus., diagrams, charts, tables, 5s. This publication discusses the manufacture of molybdenum steel, its properties, working and heat-treatment, and the uses of the various types.

PRAKTISCHE PHYSIK. By F. Kohlrausch. Seventeenth edition. Edited by F. Henning. B. G. Teubner, Leipzig and Berlin, 1935. Cloth, 6 × 9 in., 958 pp., diagrams, tables, charts, 32 rm. (25 per cent discount in U. S. A.) Kohlrausch's "Lehrbuch" has long been the standard treatise on physical-laboratory methods and measurements, and this new edition will be welcomed by physicists generally. The book has been thoroughly revised by a group of specialists under the direction of Dr. F. Henning, of the Physikalisch-Technische Reichsanstalt, and has been entirely reset. Additional tables and illustrations have been added and the book is somewhat larger than before. Those who are engaged in research work in pure or applied physics will find the work a valuable reference book.

PREPARATION OF ENGINEERING REPORTS. By T. R. Agg and W. L. Foster. McGraw-Hill Book Co., New York and London, 1935. Cloth, 5 × 8 in., 192 pp., charts, diagrams, tables, \$1.75. The beginner in report writing will find this work a help in presenting his material in an orderly way. The collection of the data, the arrangement of the subject matter, style, illustrations and other practical questions are discussed in a satisfactory way.

PRESS WORK PRESSURES. By C. W. Lucas. McGraw-Hill Book Co., New York and London, 1935. Cloth, 8 × 11 in., 128 pp., diagrams, tables, \$4. This volume presents the results of over one thousand tests of the pressures necessary for various operations, and is intended to guide the engineer in estimating the size of press required for a given job. The information is classified according to the operation, material, shape, and size of piece and is presented clearly and concisely. Coining, drawing, embossing, forging, seaming, curling, punching, cutting, and riveting operations are included.

Schweizerischer Verband für die Materialprüfungen der Technik (S.V.M.T.) Association Suisse pour l'Essai des Materiaux (A.S.E.M.) Diskussionsbericht Nr. 31. STRUCTURE ANATOMIQUE ET VALEUR TECHNIQUE DU BOIS. By P. Jaccard. Zurich, Switzerland, Dec., 1934. Paper, 8 × 12 in., 27 pp., illus., diagrams, charts, tables. Professor Jaccard in this book gives a report of the results of his studies of the anatomical characteristics of wood and their influence upon its engineering value.

Schweizerischer Verband für die Materialprüfungen der Technik (S.V.M.T.) Association Suisse pour l'Essai des Materiaux (A.S.E.M.) Diskussionsbericht Nr. 30. VERLEIMTECHNIK MIT KNOCHEN- UND LEDERLEIM; SPANNUNGSFREIE HOLZTROCKNUNG. Zurich, Switz., Dec., 1934. Paper, 8 × 12 in., 28 pp., illus., charts, tables. The first of these two reports discusses methods of testing bone glue and leather glue, and their proper use. The second discusses the kiln drying of lumber.

Science Museum (South Kensington). Handbook of the Collections illustrating MARINE ENGINES, History and Development. By G. L. Overton. His Majesty's Stationery Office, London, 1935. Paper, 6 × 10 in., 96 pp., illus., 2s. This pamphlet, as a recent addition to the valuable series of guidebooks issued by the Science Museum, sketches the history and development of marine engineering. Early efforts in steam propulsion and the development of paddle, screw, and internal-combustion engines and steam turbines, of boilers and propellers are outlined and illustrated from the museum collections.

SKY HIGH, the Story of Aviation. By E. Hodgins and F. A. Magoun. Little, Brown and Co., Boston, 1935. Cloth, 6 × 9 in., 414 pp., illus., \$2.75. An excellent popular history of man's efforts to conquer the air. The work was first published in 1929 and is now brought up to date by the inclusion of the important achievements of the past six years. The book is readable and accurate.

STEAM PLANT OPERATION. By E. B. Woodruff and H. B. Lammers. McGraw-Hill Book Co., New York and London, 1935. Cloth, 6 × 8 in., 368 pp., illus., diagrams, charts, tables, \$3. This book is intended to provide a working knowledge of the fundamental principles of stationary engineering. Approved methods of operating all the equipment usually found in power plants are described, and rules of procedure are outlined. Technical and practical information are combined in a useful way and presented with clearness, to form a very satisfactory textbook.

TECHNICAL AERODYNAMICS. By K. D. Wood. McGraw-Hill Book Co., New York and London, 1935. Cloth, 6 × 9 in., 330 pp., diagrams, charts, tables, \$3.50. Intended for students preparing for the design and manufacture of aircraft, this book aims to provide a simple, practical text on airplane performance and stability calculations. Fundamental principles are emphasized rather than technical details of construction and operation.

WHAT'S GOING ON

Including News of A.S.M.E. Affairs

This Month's Authors

READERS of MECHANICAL ENGINEERING need no introduction to the four distinguished engineers whose addresses at the Watt Bicentenary are published in this issue.

GEO. A. ORROK, consulting engineer, member, A.S.M.E., whose engineering experience covers the entire history of the electric-lighting industry, designed some of the largest and most modern steam engines ever used for the generation of electrical energy, at a time when the reciprocating engine was still undisputed in this field.

JOSEPH W. ROE, professor of industrial engineering at New York University, member, A.S.M.E., is well-known as a student of the history of engineering and biographer of engineers. His "Early English and American Tool Builders" remains an authority on this subject.

DEXTER S. KIMBALL, Dean of Engineering, Cornell University, past-president, A.S.M.E., himself designed and erected, for the Union Iron Works, some of the unusual steam engines described and illustrated in his address.

W. L. BATT, president, SKF Industries and president, A.S.M.E., has had that close contact with and responsible charge in industrial affairs that gives his appraisal of the many sources of Watt's greatness a real and modern meaning.

CHARLES E. LUCKE, head of the department of mechanical engineering, Columbia University, consulting engineer and member, A.S.M.E., is a specialist in thermodynamics and steam and gas power, and author of textbooks on power engineering.

ALFRED L. WEBRE, member A.S.M.E., engineer with the U. S. Pipe & Foundry Co., Burlington, N. J., writes on "Formation and Growth of Sugar Crystals in Vacuum Pans." Mr. Webre has been identified for the past thirty years with the sugar industry as designer of evaporators, vacuum pans, and heaters. He is the author of a textbook entitled "Evaporation" as well as many papers and bulletins on related subjects, presented before groups of sugar technologists.

THEODORE HATCH, instructor in industrial sanitation, Harvard Engineering School and Harvard School of Public Health, lectures on the engineering aspects of problems in industrial-disease control. He has done considerable work in research on dust, its properties, production in industry, control; in the development of sampling instruments and methods of measuring dust concentrations and size of dust particles, in the study of exhaust hoods and air-cleaning equipment, and in the design of dust-control systems for granite cutting and the pulverizing, mining, and hard-rock industries.

HENRY D. SAYER, author of the paper "Occupational Diseases" and who is associated with the Association of Casualty and Surety Executives was former Industrial Commissioner of New York State.

WARREN A. COOK, who writes on "Engineering Control of Occupational-Disease Hazard," is industrial hygienist of the Bureau of Occupational Diseases, Connecticut State Department of Health, Hartford. From 1925 to 1928 he was engaged in occupational-disease prevention for the Travelers Insurance Company. For the past seven years he has been in charge of the technical work of occupational-disease control in the Connecticut Health Department.

Another in the series of reviews of current economic topics of unusual interest to mechanical engineers is "Planning—Three Viewpoints," contributed by B. ALDEN THRESHER, a member of the Department of Economics, Massachusetts Institute of Technology.

Activities of A.S.M.E. Executive Committee

AT a meeting of the Executive Committee of The American Society of Mechanical Engineers, held on January 4, 1936, the following actions of general interest were taken.

PROGRAM FOR 1936

In a discussion of the items on which progress should be made during the administrative year it was voted to authorize the president to appoint a committee to study the relationships between the local sections of the Society and the various local engineering societies.

VICE-PRESIDENTS DESIGNATED AS COUNCILORS

Mr. Batt reported that the seven vice-presidents had been designated as the councilors for the seven geographical districts of the country in accord with the action of the Council at St. Louis and that a letter was being sent to the sections asking their cooperation. He has asked each of the seven councilors to have a report for each meeting of the Executive Committee.

CERTIFICATES OF INDEBTEDNESS

It was reported that $5000 of the issue of the Certificates of Indebtedness to members of the Society had been retired. Roy V. Wright, Erik Oberg, and W. D. Ennis were elected as the trustees of the fund.

DATE OF DALLAS MEETING

It was voted to set June 15 to 20, 1936, as the date of the Dallas Meeting of the Society.

BOILER-CODE APPOINTMENTS

Upon recommendation of the Special Committee on Boiler Code, the Executive Committee authorized the appointment of subcommittees on Ferrous Materials and Nonferrous Materials, as follows: Subcommittee on Ferrous Materials: H. LeRoy Whitney, chairman, A. J. Ely, H. J. French, H. W. Gillette, J. J. Kanter, H. J. Kerr, A. B. Kinzel, and A. E. White; Subcommittee on Nonferrous Materials: H. B. Oatley, Chairman J. J. Aull, D. K. Crampton, A. M. Houser, F. P. Huston, H. C. Jennison, E. F. Miller, and Joseph Price. The Executive Committee of Council authorized the appointment to the Main Boiler Code Committee of H. C. Boardman and W. G. Humpton.

CALVIN W. RICE MEMORIAL COMMITTEE

Upon the recommendation of the Calvin W. Rice Memorial Committee, the Executive Committee voted to assign to the Committee on Meetings and Program the responsibility for the administration of the Calvin W. Rice Memorial Lecture.

HALSEY BEQUEST

The Secretary reported that Frederick A. Halsey, member of the A.S.M.E., who died October 20, 1935, bequeathed the Society the following four books: Reuleaux' "Kinematics of Machinery," translated and edited by A. B. W. Kennedy; "Principles of Mechanism," by Willis; "Rumford's Essays," three volumes; "Metric System," by Davies. The Secretary was asked to express the appreciation of the Society and to place the books in the Engineering Societies Library.

COURTESIES FOR I.C.E.

A communication from the secretary of the Institution of Civil Engineers, London, offering the courtesy and privileges of the Institution to accredited visitors was received and acknowledged with appreciation. It reads: "The President and Council of The Institution of Civil Engineers have directed that a letter be addressed to kindred Engineering and Scientific Societies throughout the world stating that members of such Societies visiting this country, if suitably introduced, will, as a matter of courtesy, be accorded the privileges of attending the meetings of this Institution and using the Institution Library and Reading Rooms.

Further, such accredited visitors will, if they desire it, be presented with letters of introduction to members of the Institution to enable them to visit engineering works in this country.

Perhaps you will be so good as to take the necessary steps to make this known to the members of your Society."

The Sixteenth Annual Meeting of American Engineering Council

DELEGATES from the 42 member organizations of American Engineering Council, meeting in Washington, January 10 and 11, discussed the growing evidence of unity in the profession as to the formulation and dissemination of opinion on matters of public affairs. The Assembly acted upon reports from sixteen major and minor committees and subcommittees of the Council, listened to stimulating addresses at the All Engineers Dinner, attended by some 450 engineers, and left Washington with renewed expressions of the opportunities for advancing the public interest and for maintaining high professional standards through the agency of the American Engineering Council.

At the morning session at the Mayflower Hotel, January 10, President J. F. Coleman opened the meeting with an address on the essential elements in reviving the construction industry. Then followed in order a series of reports and discussions covering a wide range of subjects of timely interest to engineers.

SURVEY OF THE PROFESSION

George T. Seabury, as chairman of the Engineering and Allied Technical Committee, reported on the "Survey of the Engineering Profession" conducted by the Bureau of Labor Statistics of the U. S. Department of Labor. His report, based on returns from more than 60,000 questionnaires, the largest survey of this kind ever conducted, indicated that the findings would tend to give direction to engineering education, to choice and distribution of occupation, and to compensation of engineers. It is expected that full returns will be available in the early spring. It was voted to recommend to the Executive Committee of Council that steps be taken toward private publication of a mass of detailed information to supplement the government report.

Dr. Leonard D. White, U. S. Civil Service Commissioner, discussed the needs for a widely extended civil service to include state and local governmental bodies as well as federal, in order to uphold the professional standards of engineers in the public service. Discussion developed that classification by position is essential in the development of a suitably paid civil service. It was voted to instruct the Executive Committee to take the steps necessary to put these basic concepts into action, especially in cooperation with local and state engineering societies.

ECONOMIC BALANCE TOWARD HIGHER STANDARDS

Ralph E. Flanders presented the third progress report of the Committee on the Interrelation of Production, Distribution, and Consumption. In 108 classified questions and answers there was presented a catechism on the engineers' concept of the possibilities of an economic balance in the interests of a high standard of living for all. The report was accepted with the recommendation of the committee that all delegates study it, secure local discussion on its major objectives and detailed recommendations, and report back February 1, with the plan of presenting the report publicly as soon as possible thereafter as the engineers' contribution to the national welfare.

Charles W. Eliot, II, executive officer of the National Resources Committee, discussed the purposes and plans of that body in forwarding a state and local as well as a federal concept of planning. The need of approaching planning from a local and regional viewpoint was especially emphasized. It was voted to refer the bill (S. 2825) now before the Senate, providing for the continuation of the Federal organization on a permanent basis, to the Public Affairs Committee of Council for recommendations.

A. A. POTTER, PRESIDENT, A.E.C.

PUBLIC AFFAIRS REPORTS

The Public Affairs Committee of American Engineering Council, under the chairmanship of F. J. Chesterman, of Pittsburgh, has been organized under a new plan during the past year with several subcommittees active in studying public problems which fall within the purview of the profession. For coordination, the subcommittee chairmen are members of the national committee and steps are being taken to make the membership of subcommittees overlap with that of similar committees of national, state, and local engineering societies. As a result of this work, the reports rendered at the annual meeting cover basic findings in a broad variety of fields.

The subcommittee on the Administration of Public Works, F. M. Gunby, chairman, reaffirmed Council's past position that engineering public works of the Federal Government, in so far as practicable, should be concentrated under one qualified head.

The Water Resources Committee, headed by W. S. Conant, reiterated its belief in two fundamental needs for the formulation of a water-resources policy: (1) Complete and coordinated basic data bearing on the subject and (2) comprehensive study of water control legislation. The establishment of a body similar to the Board of Surveys and Maps of the Federal Government for the correlation of government data on water resources was recommended.

As a result of the work of the Aeronautics Subcommittee, headed by Grover Loening, the Public Affairs Committee adopted a report supporting aeronautical research by the colleges, disfavoring further investigations of the industry, recommending further studies toward the simplification of aircraft construction regulations, and favoring the placement of employees of the Bureau of Air Commerce under Civil Service.

The Committee on Competition of Government with Engineers in Private Practice, under the chairmanship of Alonzo J. Hammond, advocated the curtailment of competitive activities by government and the raising of consulting fees by public bodies to a basis comparable to private practice.

RURAL ELECTRIFICATION

R. W. Trullinger, of the U. S. Bureau of Agricultural Engineering, reported on the activities of a subcommittee, made up of members of the American Society of Agricultural Engineers, a member body of the Council, to forward the rural electrification program through the aid of engineers. It was voted that this work be continued under a committee which would be representative of the profession as a whole.

The Assembly received a report of the Committee on Patents, Dean A. A. Potter, chairman, dealing with the elimination of fraudulent practices, the use of a single signature on patent applications, the validation of joint patents, and the extension of the full rights of inventors. In addition, several specific items of legislation were presented as under consideration by the committee. It was recommended that the work of the committee be continued.

MAPPING

The Assembly adopted the recommendations of the Executive Committee that American Engineering Council establish a new Committee on Mapping and Surveys and that it endeavor to organize public opinion as to the basic need for completing the map of the United States. It was voted to support the original Temple Act to the end that its purposes be effectuated by appropriations which are to be based upon the fundamental values of mapping and not on a relief basis.

GOOD-FELLOWSHIP DINNER

The annual All Engineers Dinner of Council, held on the evening of January 10, filled the main ballroom of the Mayflower Hotel. Some 450 engineers, representing all the major branches of the profession were in attendance. Dr. Harrison E. Howe, editor, *Industrial & Engineering Chemistry*, proved a brilliant toastmaster.

Following the dinner, an engrossed resolution was tendered to J. F. Coleman in appreciation for his services as president of Council during the past two years. Dr. William McClellan, president of the Potomac Electric

Power Company and chairman of the Dinner Committee, made the presentation. He told how Mr. Coleman had been successful in carrying Council through a critical period in its history. Dean A. A. Potter was introduced as the new president of the Council. He stressed the need for solidarity of engineering opinion.

Dr. William F. Durand, chairman of the Third World Power Conference, past-president A.S.M.E., and John Fritz Medalist for 1935, discussed the deeper functions of the engineer. He stated that engineers are the custodians of natural resources such as minerals, coal, and oil but are not fully living up to their responsibility in conserving these resources. The profession, he said, must concern itself not alone with technical matters but increasingly with human and social problems.

Ralph E. Flanders, past-president of the A.S.M.E., directed his remarks toward a reply to a recent address by Walter Lippman before the American Medical Society. Mr. Lippman had stated that the engineer is a master of material resources but that the application of his material concepts does not work in solving human problems. Mr. Flanders stated that on the contrary every phase of the engineer's work is intensely human in its application and relationships. He predicted that engineering technique will carry the nation far beyond the "miserable physical standards of 1929."

The meeting was addressed also by the presidents or secretaries of each of the seven national engineering societies holding membership in Council, and by the chairman of the Sixth Conference of the Secretaries of Engineering Societies. Those present were unanimous in affirming their support to the continued leadership of Council as a unifying influence in engineering affairs.

NEW OFFICERS

Council's new president for 1936 and 1937 is Dr. A. A. Potter, Dean of the Schools of Engineering, Purdue University, who succeeds J. F. Coleman, of New Orleans. New vice-presidents are: Ralph E. Flanders, president of the Jones & Lamson Machine Co., for a two-year term; and J. S. Dodds, professor of Civil Engineering, Iowa State College, for a one-year term.

The chairmen of the Public Affairs Committee and of the Committee on Membership and Representation were made ex-officio members of the Executive Committee of Council. The present Public Affairs chairman is F. J. Chesterman. C. L. Bickelhaupt, who heads the membership group, already is a member of the Executive Committee as vice-president of Council. In addition to these, the Executive Committee includes Alonzo J. Hammond, vice-president, C. E. Stephens, treasurer, and William McClellan, chairman of the Finance Committee, who were re-elected. Frederick M. Feiker was re-elected as executive secretary of the Council.

SECRETARIES' CONFERENCE

Preceding the meeting of the Assembly of American Engineering Council, there was held on January 9 the Sixth Conference of Secretaries of Engineering Societies. Some thirty national, state, and local societies were represented. The morning program developed the possibilities and opportunities for cooperation and coordination on matters of public affairs through state societies, national societies, and the American Engineering Council.

Both at this session and at the subsequent Council session on Public Affairs, the development of local and state public affairs committees was carried forward and both meetings favored the further cooperation of present organizations to develop united action in these matters.

Speakers at the Secretaries' Conference included: J. F. Coleman, on Progress in Engineering Organization; General R. I. Rees, of New York, on Opportunities for Unity Among Engineering Organizations; and Col. J. M. Johnson, Assistant Secretary of Commerce, on the Engineer in Government and Business. Other topics included cooperation with national, state, and local secretaries; employment activities; engineering publicity; nontechnical programs; and engineering society management.

On adjournment of the Secretaries' Conference, an informal tea and reception was held at the home of Mr. and Mrs. F. M. Feiker in honor of Mr. and Mrs. J. F. Coleman and Dean A. A. Potter.

Inspection and Accrediting of Engineering Colleges Begun by E.C.P.D.

THE program of inspection and accrediting of engineering curricula, which the Engineers' Council for Professional Development offered last year to schools granting engineering degrees, has been accorded a hearty response by 34 colleges and universities in the New England and the Middle Atlantic States. Inspections in these two regions were inaugurated late in 1935 and will be actively continued during the next few months. When substantial progress has been made in these areas, it is expected that the program will be extended to engineering schools throughout the United States. The accrediting program has for its purpose the best development of engineering education by identifying those institutions that offer engineering curricula worthy of recognition as such. The second objective is to build up a list of accredited engineering schools, which it is hoped may be uniformly adopted by educational, technical, and state organizations now using dissimilar lists.

Institutions in the New England States that have applied for accrediting are: Brown University, Dartmouth College (Thayer School of Civil Engineering), Massachusetts Institute of Technology, Northeastern University, Norwich University, Rhode Island State College, Tufts College of Engineering, University of Maine, University of New Hampshire, University of Vermont, Worcester Polytechnic Institute, and Yale University.

In the Middle Atlantic States the following schools have applied: Alfred University, Bucknell University, Carnegie Institute of Technology, Clarkson College of Technology, College of the City of New York, Columbia University, Drexel Institute, Johns Hopkins University, Lafayette College, Manhattan College, New York University, Newark College of Engineering, University of Pittsburgh, Polytechnic Institute of Brooklyn, Princeton University, Rensselaer Polytechnic Institute, Rutgers University, Stevens Institute of Technology, Swarthmore College, Syracuse University, Union College, Webb Institute of Naval Architecture.

Engineers' Council for Professional Development is a conference of seven engineering bodies concerned with the technical, educational, and legislative interests of engineers. Its object is to enhance the status of the engineer. The constituent bodies are: American Society of Civil Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Mining and Metallurgical Engineers, American Institute of Chemical Engineers, Society for the Promotion of Engineering Education, and National Council of State Boards of Engineering Examiners. By unanimous action these organizations authorized E.C.P.D. to act as an accrediting agency. This it does through the activities and on the recommendations of its Committee on Engineering Schools headed by Dr. Karl T. Compton, President, Massachusetts Institute of Technology. Other major committees of E.C.P.D. give their attention to selection and guidance of prospective engineering students, further professional training of young engineering graduates, and the development of standards of professional recognition. Headquarters of E.C.P.D. are at 29 West 39th Street, New York City. Charles F. Scott is chairman and George T. Seabury, secretary.

A.M.A. to Discuss Industrial Relations Problems

ON February 5, 6, and 7, 1936, the American Management Association will hold a conference on "Today's Major Personnel Problems" at the Palmer House in Chicago. The conference is one of the usual meetings of the Personnel and of the Office Management Divisions of the Association. This year the Industrial Relations Association of Chicago is cooperating.

The meeting promises to be of unusually great interest because of the problems of management that face American business executives under recovery conditions and under the new Federal laws.

Among the speakers will be: Tom Girdler, chairman of the Board, Republic Steel Corporation; Dean William H. Spencer, School of Business, University of Chicago; M. B. Folsom, treasurer, Eastman Kodak Company; J. Douglas Brown, director, Industrial Relations Section, Princeton University; S. F. Shattuck, vice-president, Industrial Relations, Kimberly-Clark Corporation; and other executives of the very large and of smaller companies. James O. McKinsey, chairman, Marshall Field & Company, will preside at the dinner meeting.

1935 Census of Business

MECHANICAL - engineering firms are among the business-service groups being included in the Census of Business, which began January 2, 1936, covering the calendar year 1935. Other groups in the business-service field to be included are architects, civil engineers, accountants, advertising counselors, statistical reporting services, public-relations counselors, and sales consultants. These professional groups have a vital part in modern business, hence their inclusion in this broad measurement of American business.

All mechanical-engineering firms will be canvassed for reports on their 1935 operations. The information will include legal form of organization, number of active proprietors and firm members, paid employees and pay rolls, receipts in 1935, and other supplemental facts.

Whereas the first census comparable to the present project, covering 1929, was limited primarily to the distribution field; and the second project, the Census of American Business for 1933, was limited to distribution, service businesses, amusement enterprises, and hotels; the 1935 Census of Business will cover the following fields: retail trade, wholesale trade, insurance, real-estate, construction, banking, finance, business services, broadcasting, advertising agencies, hotels, amusements, distribution of manufacturers' sales, trucking, warehousing, bus transportation, and operation of nonresidential buildings.

With the broader field covered this year, the Bureau will be able to supply for the first time the answer to the question of how many concerns there are in business, the total volume of business that is done annually, and the total pay rolls and employment by kinds of business.

Headquarters for the project is Philadelphia. Fred A. Gosnell, experienced head of former business census, is chief statistician in charge. The field work will be completed within three months after the enumeration starts, and preliminary reports will be available by next July, if not earlier.

Only sworn employees of the Bureau of the Census are permitted to examine the individual returns. No access to them is permitted under the law, not even to other Governmental agencies, and no information will be disclosed which would reveal any of the facts or figures in the returns.

U.E.T. Elects Officers

AT a meeting of the United Engineering Trustees, Inc., October 24, George L. Knight, member, A.S.M.E., vice-president in charge of mechanical operations, Brooklyn Edison Company, was elected president. Other officers elected were Otis E. Hovey, member, A.S.M.E., vice-president; John Arms, member, A.S.M.E., secretary; and Albert Roberts, assistant treasurer.

Representatives of The American Society of Mechanical Engineers on the Board of the United Engineering Trustees, Inc., are D. Robert Yarnall, Walter Rautenstrauch, and Harold V. Coes.

FHA Modernization Booklet

THE Federal Housing Administration, Washington, D. C., is distributing its booklet FHA-180, designed to inform the public regarding certain provisions of the National Housing Act and the advantages of using government insured modernization credit to improved business property.

Under an amendment to Title 1 of the act, the shop, factory, or industrial plant owner, handicapped by worn-out or inefficient equipment or production equipment, can now borrow funds from the FHA to modernize his plant and equipment. Modernization credit is no longer limited to $2000 for such plants. Under favorable conditions it may be extended in amounts up to a maximum of $50,000.

The booklet illustrates numerous examples of modernization, explains the Modernization Credit Plan briefly, answers obvious questions regarding the plan, and gives selections from the 27 regulations governing banking operations under Title 1 of the National Housing Act. A list of structures and properties eligible for modernization credit loans up to $50,000 is included. Copies of booklet FHA-180 may be obtained from the Federal Housing Administration.

I.S.A. Rules for the Measurement of the Flow of Fluids

THE A.S.M.E. Power Test Code Instruments and Apparatus Subcommittee on the Measurement of Fluid Flow has prepared a few copies of a translation of the third draft, April, 1935, International Standards Association Rules for the Measurement of Fluid Flow (by means of the I.S.A. standardized orifice and/or flow nozzle), for loan to those interested. The official trilingual edition of the Rules which the I.S.A. is to issue, will not be available for some time.

The subcommittee is especially interested in learning the experiences of those who have used the I.S.A. orifice or flow nozzle. Those interested in obtaining a copy, either to note or for comment, should write to W. A. Carter, 2000 Second Avenue, Detroit, Michigan.

New Appointments to Alloys of Iron Research Committee

APPOINTMENT of three representatives of the steel industry to the Alloys of Iron Research Committee of the Engineering Foundation, which is carrying on world research embracing the entire body of knowledge of steel, alloy steel, alloy iron, and cast, wrought, and pure iron, is announced by the Director of the Foundation, Dr. Alfred D. Flinn.

Dr. John Johnston, director of research of the United States Steel Corporation, was named to the Committee to represent the American Iron and Steel Institute.

Wilfred Sykes, a director of the Inland Steel Company, becomes a member-at-large, succeeding the late Dr. John A. Mathews, who was vice-president of the Crucible Steel Company of America.

The other new member is James T. Mackenzie, metallurgist and chief chemist of the American Cast Iron Pipe Company, who takes the place of R. E. Kennedy, technical secretary of the American Foundrymen's Association.

Wide advances in the use of alloys were reported by the Foundation as the result of the scientific investigations which are going on in laboratories in many countries.

"Interest in these ferrous metals is growing rapidly and use is increasing through spread of knowledge of their properties," said the report, pointing out that the Foundation's critical survey will go forward in 1936 with the support of American science and industry and of metal experts in many countries.

Engineering Literature Requested for New York State Prisons

THE director of education of the Department of Correction, State of New York, Walter C. Voll, member, A.S.M.E., has asked for magazines, drawings, courses of study, standards, and other pieces of engineering literature for use in the adult-education project being carried out in the prisons of New York State. Readers having material which is suitable for such use are asked to communicate with Mr. Voll at Clinton Prison, Dannemora, N. Y., or with the warden, Thomas H. Murphy.

Texas Tech to Hold Second Annual Welding Conference

TEXAS Technological College at Lubbock Texas, will hold its Second Annual Welding Conference on February 13 and 14, 1936. All persons interested in welding are invited to attend. Mornings will be devoted to lectures and motion pictures on various phases of welding and afternoons to exhibits and demonstrations. Manufacturers of welding equipment will display and demonstrate equipment. Inquiries should be directed to J. C. Hardgrave at the college.

M. E. Cooley Honored

MORTIMER E. COOLEY, past-president and honorary member of The American Society of Mechanical Engineers, was elected an honorary member of the American Society of Civil Engineers at its meeting in Birmingham, Ala.

Medal Awarded C. A. McCune

CHARLES A. McCUNE, member, A.S.M.E., director and secretary of the Magnaflux Corporation, was awarded the Samuel Wylie Miller memorial medal of the American Welding Society at the fall meeting of that society held on September 30, 1935, for his contributions to the promotion of modern welding processes.

President Batt to Visit Sections and Branches in South

VISITS to A.S.M.E. Local Sections and Student Branches in the South will be made by William L. Batt, president of the Society, during February and March. His addresses to the Sections will be on "Unity Begins at Home," while he will talk to the students on "The Initiation of the Young Engineer Into His Profession."

MR. BATT'S ITINERARY

February 10, Richmond, Va.
February 11, Raleigh, N. C.
February 12, Raleigh, N. C.
February 13, Charlotte, N. C.
February 14, Greenville, S. C., and Clemson College
February 17, Savannah, Ga.
February 18, Gainesville, Fla.
February 21, New Orleans, La., and Tulane University
February 24, University of Louisiana
February 26, State College of Mississippi
February 27, University of Alabama
February 28, Birmingham, Ala., evening meeting
March 2, Chattanooga, Tenn., and Atlanta, Ga.
March 3, Atlanta, Ga., Local Section meeting with Georgia School of Technology Student Branch
March 4, Knoxville, Tenn., and University of Tennessee
March 5, Virginia Polytechnic Institute
March 6, University of Virginia

Air Hygiene Foundation of America, Inc.

AIR Hygiene Foundation of America, Inc. has been formed by a large group representing various industries, with headquarters at Thackeray Ave. and O'Hara St., Pittsburgh, Pa. The purposes of this organization are to conduct investigations of and to stimulate research on problems in the field of air hygiene and to gather and disseminate factual information relating thereto. It will also cooperate with and assist other agencies active in this field and will collaborate in the coordination of such research efforts. A comprehensive investigation has been begun at Mellon Institute of Industrial Research, Pittsburgh, under support of Air Hygiene Foundation of America, in which the hygienic, technologic, and economic aspects of air contamination, especially by dust met with in the industries, will be studied.

H. B. Meller, who has been appointed managing director of Air Hygiene Foundation of America, will head this investigation at Mellon Institute. He will be aided by Dr. F. F. Rupert. Other assistants will be added to the staff of the Foundation as the work progresses.

The investigational program will also embrace medical considerations and studies. The medical adviser will be Dr. Samuel R. Haythorn, professor of preventive medicine in the School of Medicine of the University of Pittsburgh and director of the Singer Research Laboratories, N. S., Pittsburgh.

A.S.M.E. Semi-Annual Meeting at Dallas, Tex., June 15–20

THE program for the Semi-Annual Meeting to be held at Dallas from June 15 to 20 is now being developed. E. W. Burbank, chairman of the North Texas Section, is organizing the local arrangements. The technical program will have sessions on Petroleum, Process Industries, Machine Shop, Power and Fuels, Hydraulic, Management, and Fluid Control.

Papers that are to be preprinted in Transactions in advance of the meeting must be submitted for consideration by March 15.

Use of the A.S.M.E. Pin

UPON recommendation to the Council of the A.S.M.E. at the Annual Meeting in December, 1935, by the Special Committee on the Use of Society Pin, the following recommendations were voted: That the use of the present standard form of badge, i.e., the blue enamel, should be restricted to Fellows, Members, and Associate-Members; (2) that for Associates the standard size badge should be permitted but the enamel should be a dark green; (3) that the Junior and Student designs should be continued as at present.

A Member's Responsibility in Indorsing a Candidate for Admission to the A.S.M.E.

THE Standing Committee on Admissions (formerly Membership Committee) has built up a procedure or tradition regarding standards for admission to membership in which the changes are few, constituting an evolution in the stiffening of requirements rather than radical changes of policy.

Because the committee welcomes all real assistance that it can secure from the membership at large, individually or by Sections, it wishes to set forth some of its operating methods.

INFORMATION SENT TO REFERENCES

When an application is received, the pertinent information contained therein is sent to the references furnished by the applicant. It might be assumed that these references are individuals prejudiced favorably to the candidate, but it has been found that this is by no means the case. In other words, members have a high regard for the Society and frequently, intentionally or otherwise, give the committee information which is not favorable. The reference forms, when returned, are distributed in books, one to each member of the committee, about a week before its monthly meeting, and each member makes his own notations and records his own opinion. At the meeting, a preliminary vote is taken, after which, discussion generally takes place before a final vote is taken. Not infrequently, the committee regards the information supplied by the candidate as insufficient and the applicant is asked for additional information or elaboration, or is asked specific questions regarding his record. Frequently all the references do not reply or replies are of an unsatisfactory character either in kind or detrimental to the candidate.

Frequently, all five or more references check for the definite grade of Member, or other grades as the case may be, but comments are such that the Committee does not believe the reference understands the constitutional requirements, or for one reason or another the affirmative vote is not satisfactory to the Committee. In spite of the request contained in the form to the reference for reasons a member should receive a certain grade, often no reason is given. The sheet is merely endorsed "Yes" and many times not even that comment is made. The reference simply checks a definite grade. In such cases, if the applicant fails to have a majority of positive endorsements and the professional record is not thoroughly convincing, recommendation to Council is witheld until further investigation is completed to the Committees' satisfaction.

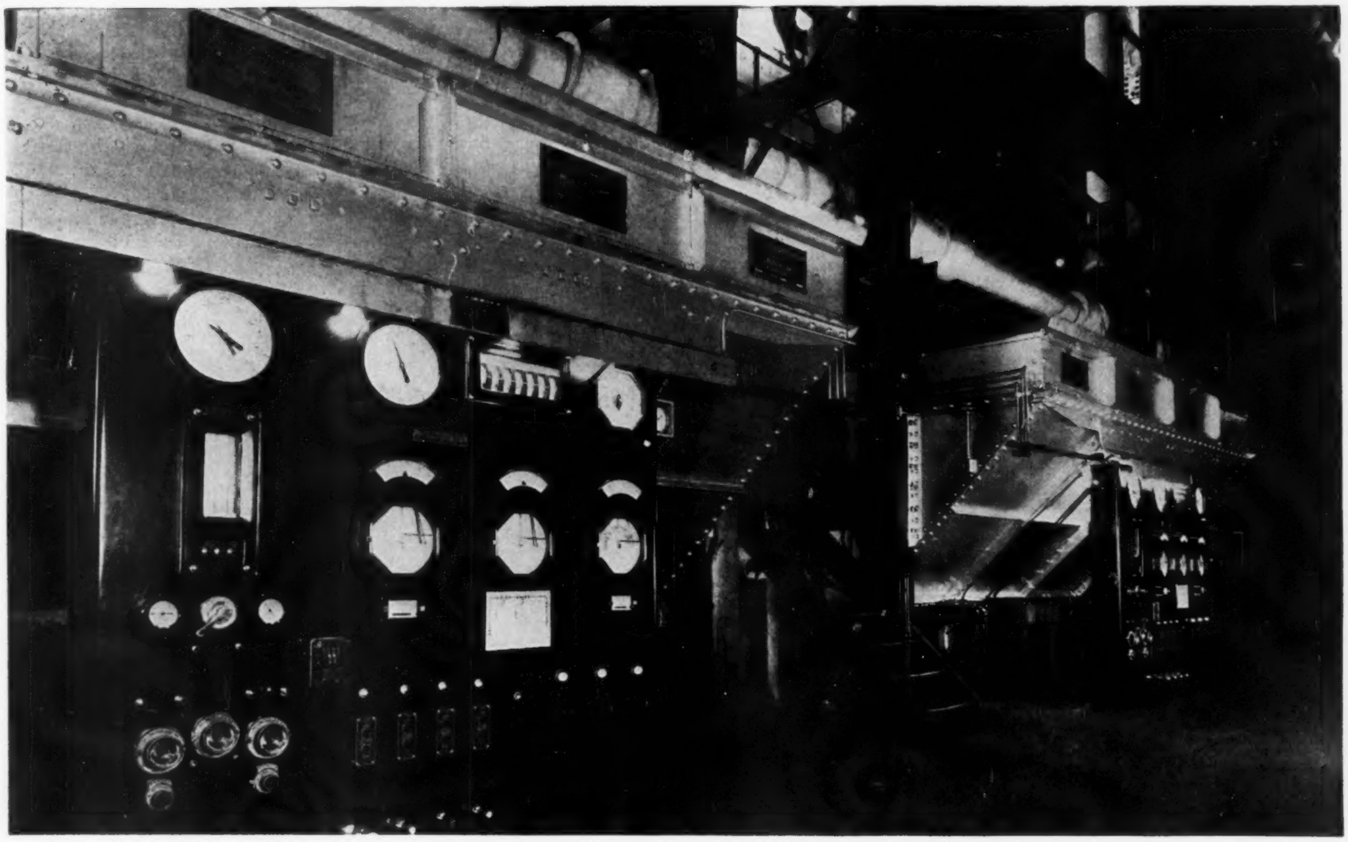
CONSTITUTIONAL REQUIREMENTS NOT UNDERSTOOD

A great difficulty which can only be appreciated by those of us who have served and have become thoroughly imbued with the traditions of the Admissions Committee is that so few members, even in the case of some of our most prominent ones, fully realize the requirements. Because an applicant is active in his section, of pleasing personality and high character, constitutional requirements of the simplest kind are overlooked. For instance, every now and then word is received from a local section when a case is referred to it, that the candidate should be admitted to the grade he asks for "because he has higher qualifications than many of the existing members." That kind of a reply has absolutely no weight with the Admissions Committee and results in a poor opinion of the person making such a reply. No doubt there are men in the Society who are not of membership caliber in spite of the care taken, but that is no excuse for increasing the number of such members. There have been cases where a statement such as the following is made: "This applicant is an exceptionally able engineer and should be given the grade of Member, although he is several years below the age limit required by the Constitution. I recommend that the Committee waive this Constitutional requirement in this case." Needless to say, the Committee can pay no attention to such a recommendation, frequently made by prominent members who ought to know better.

APPLICATIONS PUBLISHED

All applications for membership are published by the Society in ample time for any one interested to look them over and send a confidential communication to the Committee, but such comments are rarely received. Members apparently are either not willing to take

View of Smoot Control and Republic Instrument Panels installed in a modernized power station of the New York, New Haven, and Hartford Railroad



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the trouble or do not care to become involved in a matter of this kind. The Committee believes that it is the duty of every member to take such action, and while he need not recommend one way or another, he should give facts which he believes should be considered by the Committee.

The Engineers' Council for Professional Development which includes a committee from The American Society of Mechanical Engineers and which has the cooperation of the four Founder Societies, the Society for the Promotion of Engineering Education, the American Institute of Chemical Engineers, and the National Council of State Boards of Engineering Examiners, which is interested in state licensing, has given much consideration and is continuing to do so, in regard to the uniformity of requirements for engineering degrees, standard grades of membership, and standard forms for requirements by state licensing boards and by the engineering societies, all looking to professional recognition on a uniform basis. In due course, it is anticipated that individual examinations may be undertaken which will have such universal approval that qualifications may be more easily and accurately determined, but until such standards are set up and mutually agreed upon, the Committee on Admissions feels that its present procedure is adequate and may be counted upon to maintain a high standard, if the membership at large charge themselves with a share of the responsibility.

HENRY A. LARDNER, *Chairman*
Committee on Admissions

Meeting Places of Local Engineering Groups

IT HAS been suggested that for the benefit of those members who travel regularly, or even occasionally, there be published a list of the meeting places of local engineering groups, with especial mention of those groups who hold weekly luncheons.

Atlanta: Atlanta Athletic Club, 166 Carnegie Way, Mondays at 12:30 p.m.

Baltimore: Engineers' Club, 6 W. Fayette St., daily except Sundays from 12:00 to 2:00 p.m.

Boston: Engineers' Club, 2 Commonwealth Ave., third Thursday of each month at 6:30 p.m.

Buffalo: King Arthur Restaurant, Delaware Ave., second Tuesday of each month at 6:30 p.m.

Chicago: Chicago Engineers' Club, 314 Federal St., Tuesday at 12:15 p.m.

Charlotte: Efirds' Department Store, every other Monday at 1:00 p.m.

Cincinnati: Engineers' Club Rooms, Ninth and Race Sts., at 8:15 p.m., fourth Thursday of each month.

Cleveland: Hotel Statler, Cafeteria, Euclid Ave., Wednesdays at 12:30 p.m.

Colorado: Chamber of Commerce, Sixth floor, 1726 Champa St., Denver, fourth Friday of each month at 6:30 p.m.

Columbus: Engineers' Club, Chittenden Hotel, Spring and High Sts., 12:00 noon, third Friday of each month.

Inland Empire: Davenport Hotel, Spokane, Wash., Wednesdays at noon.

Indianapolis: Rose Polytechnic Institute, Terre Haute, Ind., luncheon daily.

Knoxville: Knoxville Technical Club every Monday at 12:30 p.m. at the Andrew Johnson Hotel.

Los Angeles: Engineers' Club, Biltmore Hotel, 515 South Olive St., Los Angeles, Calif. Thursdays at noon.

Milwaukee: Wisconsin Club, 900 W. Wisconsin Ave., third Wednesday at 8:00 p.m.

Ontario: Faculty Union Room, Hart House, University of Toronto, second Thursday of each month at 6:15 p.m.

Philadelphia: Engineers' Club, 1317 Spruce St., fourth Tuesday of each month at 6:00 p.m.

Providence: Providence Engineering Society Building, 195 Angell St., first Tuesday of each month at 8:00 p.m.

Rochester: Sagamore Hotel, 111 East Ave., Tuesday at 12:15 p.m.

St. Louis: Washington Univ. Campus, Lindell & Skinner Boulevards, fourth Friday of each month at 8:15 p.m.

San Francisco: Engineers' Club of San Francisco, 206 Sansome St., Thursdays at noon.

Western Massachusetts: Hotel Highland, Hillman St., Springfield, Mass., third Tuesday of each month at 6:30 p.m.

Western Washington: Engineers' Club, Arctic Building, Seattle, Wash., luncheon daily at noon.

Worcester: Worcester Polytechnic Institute, Worcester, Mass. Time varies.

Youngstown: Republic Rubber Club House, Albert Street, fourth Monday of each month.

Coming Meetings of A.S.M.E. Local Sections

Youngstown: February 24. Republic Club House, Albert St., Youngstown, Ohio. A speaker from the Republic Steel Corporation will provide moving pictures and sound recording, showing the manufacture and application of stainless steel.

Candidates for Membership in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after February 25, 1936, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member having comments or objections should write to the secretary of the A.S.M.E. at once.

NEW APPLICATIONS

BEALING, ERNEST, York, England
BERGNER, H. W., Chicago, Ill.
BRINKMAN, CHAS. F., Newark, N. J. (Rt)
CRONIN, ARTHUR D., Detroit, Mich.
CROSS, B. J., New York, N. Y.
ERWIN, ROBT. M., La Habra, Calif.
GADDIS, H. L., Dallas, Tex.
GIANGRANDE, VINCENT J., New York, N. Y.
HIGGINS, ALEXANDER, Calgary, Alberta, Can.
HILLE, EDWARD, Forest Hills, L. I., N. Y.
KRANICH, HENRY O., Toledo, Ohio
KRAUSE, ROBT., Chicago, Ill.
LAIRD, I. LAVREN, Walpole, Mass.
LAWRENCE, JAS. V., Long Island City, N. Y.
LERCH, WERNER E., Long Island City, N. Y.
MARX, ERICH, New York, N. Y.
NAGOSHINER, GEO., New York, N. Y.
NICOLAI, A. LEWIS, New York, N. Y.
OLIKER, HERMAN, Brooklyn, N. Y.
RABE, J. S., Philadelphia, Pa.
SCHOENFELD, ED., JR., Montrose, N. Y.
SINGH, KISHAN, Jamshedpur, India
STRAUSS, JEROME, Bridgeville, Pa. (Rt & T)
TOROK, ELMER, Elizabethton, Tenn. (Rt)
VAN DYKE, JOS. J., Jackson Heights, L. I., N. Y.
WADDELL, C. L., Morristown, N. J.
WARNER, LESLIE T., Concord, N. S. W., Australia
WILLIAMS, ARTHUR, Hammond, Ind.
ZAHEL, ALEX., Yorktown Heights, N. Y.

CHANGE OF GRADING

Transfers from Junior

ENGLE, DANIEL E., Akron, Ohio
HOAGLAND, CECIL N., Bridgeport, Conn.
NICASTRO, GEO. J., Woodcliff, N. J.

Necrology

THE following deaths of members have recently been reported to the Office of the Society:

CONNOR, HERBERT R., May, 1935
HOWE, RALPH W., October 23, 1935
LAND, FRANK, December 24, 1935
LEWIS, DAVID J., JR., December 26, 1935
ROSSMASSLER, CARL, December 28, 1935
TURNER, ROBERT T., November 13, 1935

A.S.M.E. Transactions for January, 1936

THE January, 1936, issue of the Transactions of the A.S.M.E., contains the following papers:

Engineering Problems in Aircraft Operation in High Altitudes (AER-58-1), by R. E. Johnson and R. F. Gagg

The Flow Characteristics of Variable-Speed Reaction Steam Turbines (FSP-58-1), by Adolf Egli

Distribution of Air to Underfeed Stokers (FSP-58-2), by A. S. Griswold and H. E. Macomber

Film-Lubrication Theory and Engine-Bearing Design (OGP-58-1), by E. S. Dennison

Locomotive and Car Journal Lubrication (RR-58-1), by E. S. Pearce

A Study of the Turning of Steel Employing a New-Type Three-Component Dynamometer (RP-58-1), by O. W. Boston and C. E. Kraus

DISCUSSION

On previously published papers by S. D. Mitereff; O. R. Wikander; and F. F. Fisher and E. T. Cope.

For closing dates on discussion, see footnote on first page of each paper.